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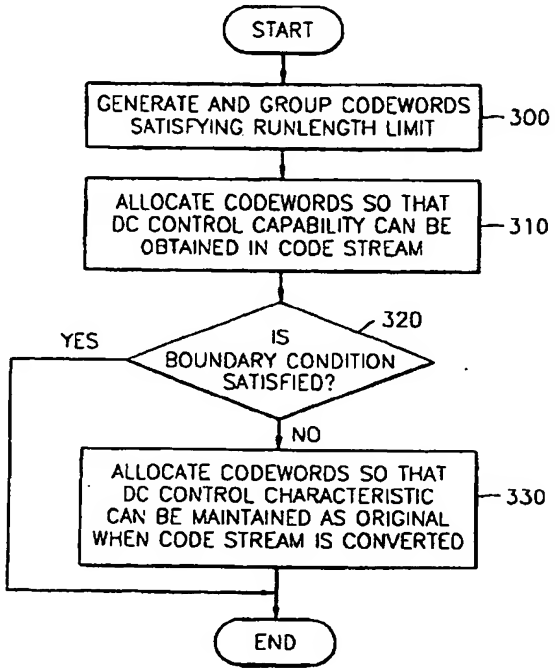
(54) Code generation and allocation method

(57) A method for generating and allocating codewords is provided. The method includes allocating one of two selectable codewords b1 and b2 as codeword b when a preceding codeword a and a following codeword b form a code stream X, in which codewords b1 and b2 have opposite INVs which are parameters indicating whether the number of '1s' contained in a codeword is an odd number or an even number and when the code stream of a and b1 is X1, and the code stream of a and b2 is X2, allocating codewords such that the INVs of X1 and X2 are maintained to be opposite when a or b1(b2) should be replaced by another codewords in compliance with a predetermined boundary condition given between codewords. According to the method, by using a short codeword having less bits as a main conversion codeword, high efficiency is achieved in recording density. Also, when codewords which do not satisfy the run length conditions are replaced by other codewords, the codewords are allocated so that the DC suppression capability of the code stream can be maintained, and therefore higher DC suppression capability of the code stream is provided.

FIG. 3



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Description

[0001] The present invention relates to generation and allocation of modulation codes of source codes to be recorded on a recording medium, and more particularly, to a method for generating and allocating codewords in which codewords having a restricted run length are generated and the generated codewords are allocated so that the DC control characteristic of a code stream is maintained.

[0002] In a Run Length Limited (RLL) code represented by (d, k, m, n), the performance of a code is evaluated mainly based on the recording density and the capability to suppress the DC component of the code. Here, m denotes the number of data bits (the number of so-called source data bits, which is also referred to as the number of information word bits), n denotes the number of codeword bits after modulation (the number of so-called channel bits), d denotes the minimum number of a series of '0s' that can exist between '1' and '1' in a codeword, and k denotes the maximum number of a series of '0s' that can exist between '1' and '1' in a codeword. The interval between bits in a codeword is represented by T.

[0003] In a modulation method, to improve recording density it is used to reduce the number of codeword bits n while regarding d and m as given conditions. In the RLL code, however, d which is the minimum number of a series of '0s' that can exist between '1' and '1' in a codeword, and k which is the maximum number of a series of '0s' that can exist between '1' and '1' in a codeword, should be satisfied. If, with this (d, k) condition satisfied, the number of data bits is m, the number of codewords satisfying RLL(d, k) should be equal to or greater than 2^m. Moreover, in order to actually use this code, run length constraints, that is, RLL(d, k) conditions, should be satisfied in a part where a codeword is linked to another codeword. In addition, when the DC component of a code affects the system performance, it is desirable to use a code which has a DC suppression capability.

[0004] The main reason for suppressing the DC component in the RLL modulated code stream is to minimize a reproducing signal's affect on a servo band. Hereinafter, methods for suppressing the DC component will be referred to as Digital Sum Value (DSV) control methods.

[0005] DSV control methods can be broadly classified into two types. One is a method having a DSV control code itself, where the DSV control code is capable of controlling a DSV. The other is a method of inserting a merge bit at each DSV control time. An Eight to Fourteen Modulation plus (EFM+) code performs DSV control using a separate code table, while an EFM code or a (1, 7) code performs DSV control by inserting a merge bit.

[0006] Therefore, the shape of the prior art modulation code group having the DSV control code itself capable of controlling suppression of the DC component and satisfying the conditions described above is as shown in Figure 1, in which each of a predetermined number of main conversion code groups has a corresponding code group for controlling suppression of the DC component. Each main conversion code group and its corresponding code group form a pair so that the DC component can be suppressed and controlled. In this case, there are some characteristics that distinguish codewords of the predetermined main conversion code groups. That is, there are no identical codewords between the main conversion code groups A and B. If duplicated codes are used, there might be the conversion code groups C and D for demodulating the duplicated codes, where there are no identical codewords between the conversion code groups C and D, but codewords in the code group A or B may be in the code group C or D for demodulating duplicated codes. The number of codewords in the main conversion code groups A and B and the conversion code groups C and D for demodulating duplicated codes is 2^m if the number of bits in the source word before conversion is m.

[0007] If code groups E through H are DC suppression control code groups used for suppressing DC components together with code groups A through D, respectively, the characteristics of codewords in each of the code groups E through H are the same as the characteristics of codewords in the main code groups A through D respectively. That is, the same conditions for generating duplicated codewords or the same conditions for determining the number of lead zeros in a codeword are applied to each of the DC suppression control code groups E through H for controlling suppression of DC components and the conversion code groups A through D.

[0008] For example, the characteristics of the EFM+ code, which is used in current Digital Versatile Discs (DVD), has a run length condition of RLL(2, 10) and a codeword length (n) of 16 bits, is as shown in Figure 2. The main conversion code groups are MCG1 ("A" in Figure 1) and MCG2 ("B" in Figure 1) and the conversion code groups for demodulating duplicated codes are DCG1 ("C" in Figure 1) and DCG2 ("D" in Figure 2). There are four DSV code groups ("E~H" in Figure 1) which make pairs with respective conversion code groups to control suppression of DC components. There are no identical codewords between the four conversion code groups and the four DSV code groups which are code groups for controlling DC components.

[0009] Also, the conditions for generating duplicated codewords in the entire code groups are the same, and the characteristics of codewords in each code group pair that can control DC components (MCG1 and the first DSV code group, MCG2 and the second DSV code group, DCG1 and the third DSV code group, or DCG2 and the fourth DSV code group) are the same.

[0010] That is, a codeword having a continuous sequence of from 2 to 5 zeros from the Least Significant Bit (LSB) of the codeword is generated using duplicated codewords. This rule is applied to each code group in the same manner.

In each of the codewords of the first DSV code group for controlling suppression of DC components, which controls suppression of DC components together with the main conversion code group MCG1, there is a continuous sequence of between 2 and 9 '0s' from the Most Significant Bit (MSB). In each of the codewords of the second DSV code group for controlling suppression of DC components, which controls suppression of DC components together with the main conversion code group MCG2, there is either 0 or 1 '0' continuing from the MSB. Some bits (here, b15(MSB) or b3) in the codewords of the third DSV code group for controlling suppression of DC components, which controls suppression of DC components together with the conversion code group DCG1 for demodulating duplicated codes are '0b', while some bits (here, b15(MSB) or b3) in the codewords of the fourth DSV code group for controlling suppression of DC components, which controls suppression of DC components together with the conversion code group DCG2 for demodulating duplicated codes, some bits (here, b15(MSB) and b3) are '1b". In developing 8 to 15 modulation code which has an advantage in the recording density aspect compared to the prior art modulation method EFM+ which uses the modulation code group shown in Figure 1 or 2, the original characteristics of a code stream change when a change occurs in a codeword because of a boundary rule applied to the locations adjacent to a boundary which connects a codeword to another codeword.

[0011] It is an aim of the present invention to provide a method for generating and allocating codewords in which a codeword having a run length restriction is generated and the codeword is allocated so that the original characteristics of a code stream are maintained without change even when a codeword is replaced according to the boundary rule when a code stream is allocated.

[0012] According to a first aspect of the present invention there is provided a method for generating and allocating codewords of source words which are to be recorded on a recording medium, the method including generating codewords satisfying predetermined run length conditions and grouping codewords according to each run length condition; and allocating the codewords such that a code(word) for the source word is capable of controlling suppression of DC components.

[0013] It is preferable that when a predetermined boundary condition is not satisfied in the code stream, allocating codewords such that codewords which satisfy the boundary condition and maintain the DC control characteristics which are considered when the initial codewords are allocated replace the initial codewords.

[0014] It is preferable that the step for generating codewords includes generating codewords satisfying the length of a predetermined first codeword, and predetermined run length conditions, grouping the codewords according to each predetermined run length condition to generate a main conversion codeword table; generating DC control codewords satisfying the length of a predetermined second codeword, and predetermined run length conditions in order to control DC components in the code(word) stream, grouping the DC control codewords, and to generate a code conversion table for controlling DC components; and generating additional DC control codewords by taking codewords which satisfy the predetermined run length conditions and are not needed in the main conversion codeword table, and grouping the additional DC control codewords.

[0015] According to a second aspect of the present invention there is provided an allocation method for allocating codewords generated for source words to be recording on a recording medium, the method including when a preceding codeword a and a following codeword b form a code stream X, allocating one of two selectable codewords b1 and b2 as codeword b, in which codewords b1 and b2 have opposite INVs which are parameters indicating whether the number of '1s' contained in a codeword is an odd number or an even number and when the code stream of a and b1 is X1, and the code stream of a and b2 is X2, allocating codewords such that the INVs of X1 and X2 are maintained to be opposite when a or b1(b2) should be replaced by another codewords in compliance with a predetermined boundary condition given between codewords.

[0016] It is preferable that when the predetermined boundary condition is that the number of continuous '0s' between codewords should be at least 2, and when the number of continuous '0s' from the Least Significant Bit (LSB) of the codeword a in the Most Significant Bit (MSB) direction is 0, and the number of continuous '0s' from the MSB of the codewords b1 or b2 in the LSB direction is 1, code changes of either the codeword a or b1(b2) occur to satisfy the boundary condition.

[0017] It is preferable that when the number of continuous '0s' between the codewords a and b is 1 or 0, the codeword a or b is changed such that the number of 0s forming the boundary is greater than 2 and less than 10.

[0018] It is preferable that the codeword a of the code stream X1 and the codeword a of the code stream X2 are changed to other codewords such that the resulting codewords a of code streams X1 and X2 have the same INV value, and as a result, by the INVs of codewords b1 and b2 following the codewords a respectively, the INVs of the X1 and X2 become different.

[0019] According to a third aspect of the present invention there is provided an allocation method for allocating codewords of source words to be recording on a recording medium, the method including when a preceding codeword b and a following codeword c form a code stream Y, allocating one of two selectable codewords b1 and b2 as the codeword b, wherein codewords b1 and b2 have opposite INVs which are parameters indicating whether the number of '1s' contained in a codeword is an odd number or an even number and when the code stream of b1 and c is Y1, and

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the code stream of b2 and c is Y2, allocating codewords such that INVs of Y1 and Y2 are maintained to be opposite when the codeword b1, b2 or c should be replaced by another codeword in compliance with a predetermined boundary condition between codewords.

[0020] It is preferable that when the predetermined boundary condition is that the number of continuous '0s' between codewords should be at least 2, and when the number of continuous '0s from the Least Significant Bit (LSB) of the codeword c toward the Most Significant Bit (MSB) is 1, codeword b which does not satisfy the boundary condition and is xxxxxxxxxxx1001 or xxxxxxxxxx10001 appears in both b1 an b2.

[0021] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a diagram of an example of the shape of a prior art modulation code group;

Figure 2 is a table showing the prior art code group and the characteristics of codewords included in the code group;

Figure 3 is a flowchart showing a method for generating and allocating codes according to the present invention;

Figure 4 is a table showing a variety of codeword groups of main conversion tables and the characteristics of codewords in each codeword group;

Figure 5 is a table showing a variety of codeword groups of a conversion table for DC control and the characteristics of codewords in each codeword group;

Figure 6 is a table showing a variety of codeword groups of an auxiliary conversion table for DC control and the characteristics of codewords in each codeword group;

Figure 7 is a diagram for showing what should be considered for the run length conditions when codewords a and b are connected;

Figure 8 is a table showing an example of changes in INV before code conversion and after code conversion when the run length conditions described in Figure 7 are not satisfied;

Figure 9 is a diagram showing an example of code stream branching due to selective codewords b1 and b2 for DC control;

Figure 10 is a graph showing the relationship between INV values of a code stream pair;

Figures 11a through 11e are main conversion code according to the present invention;

Figures 12a through 12j are code conversion tables for DC control according to the present invention;

Figures 13a and 13b are auxiliary code conversion tables for DC control according to the present invention; and

[0022] Figure 14 is a graph showing the difference between the frequency spectrum when codewords of the code conversion table for DC control according to the present invention are used in 25% of all of the codewords, and the frequency spectrum when prior art EFM+ modulation codewords are used.

[0023] Figure 3 is a flowchart showing a method for generating and allocating codes according to a preferred embodiment of the present invention. According to the method for generating and allocating codewords of source words to be recorded on a recording medium, codewords satisfying predetermined run length conditions are generated and the generated codewords are grouped according to each run length condition in step 300. The codewords are allocated so that the code(word) streams for source words are capable of controlling DC components in step 310. It is determined whether or not predetermined boundary conditions are satisfied in the code stream in step 320. If the conditions are not satisfied, the codewords are replaced by codewords satisfying the boundary conditions while the DC control characteristics which are considered when the original codewords are allocated can be kept.

[0024] Code tables of the codewords for source code conversion are roughly divided into three types: 1) main conversion tables, 2) conversion tables for controlling DC components, and 3) auxiliary conversion tables for controlling DC components.

[0025] Figure 4 is a table showing a variety of codeword groups of main conversion tables and the characteristics of codewords in each code group. It is assumed that d denotes the minimum run length limit of a codeword, k denotes

the maximum run length limit of a codeword, m denotes the number of bits of source data, n denotes the number of bits of a codeword after modulation, End Zero (EZ) denotes the number of '0s' in a continuous sequence from the LSB of a codeword in a direction toward the MSB of the codeword, and LZ denotes the number of '0s' in a continuous sequence from the MSB of a codeword in a direction toward the LSB of the codeword. For example, codewords that satisfy d=0, k=10, m=8, n=15, 0≤EZ≤8 are divided according to the following LZ conditions:

1) number of codewords satisfying 2≤LZ≤10: 177
2) number of codewords satisfying 1≤LZ≤9: 257
3) number of codewords satisfying 0≤LZ≤6: 360
4) number of codewords satisfying 0≤LZ≤2: 262

[0026] If the number of bits of source data satisfies m=8, the number of codewords for conversion should be 256 or more. However, in condition 1), the number of codewords does not amount to 256. Therefore, the number of codewords in condition 1) can amount to 256 by taking some codewords from a condition having surplus number of codewords. In this case, 83 codewords from the codewords satisfying group 3)'s LZ condition may be taken and added to group 1). Then, the numbers of codewords included in conditions 1) through 4) are 260, 257, 277(=360-83), and 262, respectively, and satisfy the minimum number of modulation codewords, that is, 256 for 8-bit source data. In the table of Figure 4, Main Code Group 1 (MCG1) is the name of a code group containing codewords satisfying condition 1) and some (83) codewords are taken from codewords satisfying condition 3). MCG2 and MCG4 are the names of codewords satisfying condition 2), and 4), respectively. MCG3 is the name of codewords satisfying condition 3), excluding the 83 codewords taken by MCG1. In each of the main code groups MCG1 through MCG4, only 256 codewords can be used as conversion codes for source codes.

[0027] Figure 5 is a table showing a variety of codeword groups of a conversion table for DC control and the characteristics of codewords in each codeword group. For example, assuming that d=2, k=10, m=8, n=17, and 0≤EZ≤8, conversion code tables for controlling DC components may include the following 4 groups (corresponding to DCG1, DCG2, DCG3, and DCG4 of Figure 5, respectively) according to the LZ conditions:

1) number of codewords satisfying 2≤LZ≤10: 375
2) number of codewords satisfying 1≤LZ≤9: 546
1) number of codewords satisfying 0≤LZ≤6: 763
1) number of codewords satisfying 0≤LZ≤2: 556

[0028] Each group forming a conversion table for controlling DC components should have at least 2 codewords that selectively correspond to one source data, and therefore should have at least 512 ($=2^8+2^8$) codewords for 8-bit source data. Since the number of codewords in the code group satisfying the LZ condition 1) is less than 512, code group 1) can take surplus codewords from other code groups satisfying other LZ conditions to amount to the number of 512. For example, in the above embodiment, code group 1) may take 177 codewords from the code group satisfying the condition 3) so as to have 552 (=375 + 177) codewords.

[0029] Figure 6 is a table showing a variety of codeword groups of an auxiliary conversion table for DC control and the characteristics of codewords in each code group. For example, among codewords satisfying d=2, k=10, m=8, and n=15, codewords satisfying 9≤EZ≤10, the remaining codewords of the main code conversion groups (MCGs), and codewords satisfying LZ=7, 8 or LZ=4, 5 are used as codewords of auxiliary code groups (ACGs) for controlling suppression of DC components. The conditions for generating these codewords will now be explained in detail. The following conditions correspond to ACG1 through ACG4, respectively, which are names of the auxiliary conversion tables for controlling suppression of DC components:

1) 5 codewords (satisfying 9≤EZ≤10 and LZ≠0) + the remaining 4 codewords (in the MCG1) = 9 codewords,
2) 5 codewords (satisfying 9≤EZ≤10 and LZ≠0) + 1 remaining codewords (in the MCG1) = 6 codewords,
3) 5 codewords (satisfying 9≤EZ≤10 and LZ≠1) + 15 codewords (satisfying 7≤LZ≤8 and 0≤EZ≤8)= 41 codewords, the remaining 4 codewords in the MCG1 = 9 codewords,
4) 7 codewords (satisfying 9≤EZ≤10 + the remaining 6 codewords in the MCG4) + 85 codewords (satisfying 3≤LZ≤5 and 0≤EZ≤8) = 98 codewords.

[0030] When codeword a and codeword b are connected, the junction where the two codewords are connected should satisfy a run length (d, k) condition. Figure 7 is a diagram showing what should be considered for the run length conditions when codewords a and b are connected. Satisfying the run length condition means that in Figure 7 a value obtained by adding the end zero (EZ_a) of codeword a and the lead zero (LZ_b) of codeword b is equal to or greater than the minimum run length d and equal to or less than the maximum run length k.

[0031] Figure 8 is a table showing an example of changes in INV (whose meaning will be described below) before code conversion and after code conversion when the run length conditions described in Figure 7 are not satisfied. Codeword b is determined in a group indicated by the EZ of the preceding codeword, codeword a. When a or b is included in a code group which does not have enough codewords to meet the condition and takes codewords from other code groups, the (d, k) condition may not be satisfied. In this example, the EZ of codeword a changes to satisfy the run length condition, which is referred to as the boundary rule. Variable INV which indicates whether the number of '1s' in a codeword stream is an even number or an odd number may change from the previous INV while the codeword a didn't change (unclear), according to the boundary rule. Due to this characteristic, attention should be paid to allocation of a codeword between code conversion tables capable of controlling suppression of DC components.

[0032] Figure 9 is a diagram showing an example of code stream branching due to selective codewords b1 and b2 for DC control. One of the major features of the code conversion of the present invention is that the codewords of two code conversion tables that can be selected for DC control are allocated so that they have opposite INV characteristics. When the previous INV changes according to the boundary rule as described above, if the INVs of both codewords in the two code conversion tables that can be selected change, then there will be no problem. Otherwise, characteristics of codewords having opposite INV cannot be maintained. For this reason, a code conversion table is designed considering the following.

[0033] First, in A of Figure 9, that is, at the junction where the codeword a and the codeword b are connected to each other, if b1 and b2, which can be selected as codeword b, are codewords in DCG11 and DCG12, respectively, which are regrouped in the code conversion table DCG1 shown in Figure 5 after separating codewords which correspond to the same source code but have different INVs, or if b1 and b2 are codewords of MCG1 and MCG2, respectively, then codewords in which LZ_b1 (the number of LZs of codeword b1) and LZ_b2 (the number of LZs of codeword b2) is 1 are allocated on the location. By doing so, when the EZ of the codeword a is '0', according to the boundary rule, the INV of codeword a changes in both the code stream containing the codeword b1 and the code stream containing the codeword b2, or the INV of codeword a does not change in either the code stream containing the codeword b1 or the code stream containing the codeword b2, such that the INVs of the two code streams are maintained to be opposite. An example is as follows:

source data 250 224 27

code stream1(before conversion)000001000010001(MCG3) 000001000001001(MCG1) 010010010000000(MCG1)

code stream1(after conversion)000001000010001 000001000001000 010010010000000

INV1 1 1 0

code stream2(before conversion)000001000010001(MCG3) 000001000001001(MCG1) 010010000000000(ACG1)

code stream2(after conversion)000001000010001 000001000001000 010010000000000

INV2 1 1 1

[0034] Next, in B of Figure 9, that is, at the junction where codeword b and codeword c are connected to each other, if codewords b1 and b2 are respectively included in code conversion tables DCG11 and DCG12, DCG21 and DCG22, DCG31 and DCG32, DCG41 and DCG42, MCG1 and ACG1, MCG2 and ACG2, MCG3 and ACG3, or MCG4 and ACG4, and (xx)xxxxxxxxxx1001 or (xx)xxxxxxxxx10001, INV may change according to the boundary rule due to the LZ of the following codeword c. Therefore, these codewords bland b2 are allocated to the location for corresponding same source data in each table such that the INVs of the two code streams are maintained to be opposite. An example is as follows:

source data	250	152	210
code stream1(before conversion)			000001000010001(MCG3)
01000000010001001(DCG11)	000000100000001(MCG1)		
code stream1(after conversion)			000001000010000
01000000010001001	000000100000001		
INV1	0	0	0
code stream2(before conversion)			000001000010001(MCG3)
01001000010001001(DCG12)	010000001001001(MCG1)		
codes tream2(after conversion)			0000010000100000
01001000010001001	010000001001001		
INV2	0	1	1

[0035] For the junctions A and B of Figure 9, the codewords are first allocated to the location corresponding same source data in each code conversion table (DCG11 and DCG12 or MCG1 and ACG1) considering above. Referring to the following example, in point B, according to the boundary rule, the INVs of code stream1 and code stream2 are maintained to be opposite and the INVs of code stream3 and code stream4 are maintained to be opposite. Also, at point B, according to the boundary rule, the INVs of code stream1 and code stream3 are maintained to be opposite and the INVs of code stream2 and code stream4 are maintained to be opposite.

source data	250	152	7
code stream1(before conversion)			000001000010001(MCG3)
01000000010001001(DCG11)	010000010010001(MCG1)		
code stream1(after conversion)			000001000010000
01000000010001000	010000010010001		
INV1	0	1	1

code stream2(before conversion) 000001000010001(MCG3)
01000000010001001(DCG11) 0100100100100001(ACG1)
code stream2(after conversion) 0000010000100000
0100000001000100 0100100100100001
INV2 0 1 0
code stream3(before conversion) 000001000010001(MCG3)
01001000010001001(DCG12) 0100000100100001(MCG1)
code stream3(after conversion) 000001000010000
0100100001000100 0100000100100001
INV3 0 0 0
code stream4(before conversion) 000001000010001(MCG3)
01001000010001001(DCG12) 0100100100100001(ACG1)
code stream4(after conversion) 0000010000100000
0100100001000100 0100100100100001
INV4 0 0 1

[0036] As described above, considering changes in the INV of a codeword due to the boundary rule in a codeword stream, codewords are allocated so that the INV polarities of a codeword pair after modulation is always be maintained to be opposite. Figure 10 is a graph showing the relationship of INV values of this code stream pair. If codewords are allocated such that the INV values of a code stream pair are always opposite, a codeword can be selected so that a code stream which is DC components between the code stream pair is formed.

[0037] Exceptions to the rule that INV values are maintained to be opposite at point A of Figure 9 may occur when source data is from 251 to 255 in the code conversion table for controlling DC components. In such exceptional cases, the CSV signs of codewords are made to be opposite so that the difference between DSV values in the code stream pair is made.

[0038] Figures 11a through 11e are main conversion code tables in which codewords are generated and allocated considering conditions described above.

[0039] Figures 12a through 12j are code conversion tables for DC control in which codewords are generated and allocated considering conditions described above.

[0040] Figures 13a and 13b are auxiliary code conversion tables for DC control in which codewords are generated and allocated considering conditions described above.

[0041] Figure 14 is a graph showing the difference between the frequency spectrum when codewords of the code conversion table for DC control according to the present invention are used in 25% of all of the codewords, and the frequency spectrum when prior art EFM+ modulation codewords are used. The graph shows that in a low frequency band, the frequency spectrum of the modulated code stream according to the present invention is almost the same as the frequency spectrum of the EFM+, which indicates that the code stream of the present invention has almost the same capability of suppressing DC components as that of the EFM+ method.

[0042] Accordingly, since the present invention uses 15-bit codes as the main conversion code and selectively uses 17-bit DC control codes for controlling DC components, the present invention has better efficiency in recording density than the prior art EFM+ code and has the same DC suppression capability as the EFM+ code.

[0043] In the present invention, by using a short codeword having less bits as a main conversion codeword, high efficiency is achieved in recording density.

[0044] Also, when codewords which do not satisfy the run length conditions are replaced by other codewords, the codewords are allocated so that the DC suppression capability of the code stream can be maintained, and therefore higher DC suppression capability of the code stream is provided.

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[0045] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0046] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0047] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0048] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A method for generating and allocating codewords of source words which are to be recorded on a recording medium, the method comprising:

   generating codewords satisfying predetermined run length conditions and grouping codewords according to each run length condition; and

   allocating the codewords such that a codeword for the source word is capable of controlling suppression of DC components.

2. The method of claim 1, further comprising:

   when a predetermined boundary condition is not satisfied in the code stream, allocating codewords such that codewords which satisfy the boundary condition and maintain the DC control characteristics which are considered when the initial codewords are allocated replace the initial codewords.

3. The method of claim 1 or 2, wherein in order to make code streams capable of controlling suppression of DC components allocating codewords such that a pair of codeword streams having opposite INV characteristics are made selectable, where INV indicates whether the number of '1s' is an odd number or an even number.

4. The method of claim 1, 2 or 3, wherein the step for generating codewords comprises:

   generating codewords satisfying the length of a predetermined first codeword, and predetermined run length conditions, grouping the codewords according to each predetermined run length condition to generate a main conversion codeword table;

   generating DC control codewords satisfying the length of a predetermined second codeword, and predetermined run length conditions in order to control DC components in the code(word) stream, grouping the DC control codewords, and to generate a code conversion table for controlling DC components; and

   generating additional DC control codewords by taking codewords which satisfy the predetermined run length conditions and are not needed in the main conversion codeword table, and grouping the additional DC control codewords.

5. The method of claim 4, wherein when the bit length of the source word is 8, the length of a codeword in the main conversion code table is 15 bits.

6. The method of claim 5, wherein the main conversion code table contains groups of codewords, the groups formed of a group of codewords each having from 2 to 10 Lead Zeros (LZs), a group of codewords each having from 1 o 9 LZs, a group of codewords each having from 1 to 6 LZs, and a group of codewords each having from 0 to 2 LZs, while having from 0 to 8 End Zeros (EZs).

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7. The method of claim 6, wherein among the groups of the main conversion code table, a group having a lesser number of codewords than the minimum number of codewords for converting the source data takes surplus codewords from a group having a greater number of codewords than the minimum number of codewords so as to amount to the minimum number of codewords.

8. The method of claim 5, wherein the length of the codewords of the DC control conversion code table is 17 bits.

9. The method of claim 8, wherein the DC control conversion code table contains groups of codewords, the groups formed of a group of codewords of which LZ is from 2 and to 10, a group of codewords of which LZ is from 1 to 9, a group of codewords of which LZ is from 0 to 6, and a group of codewords of which LZ is from 0 to 2, while EZ is from 0 to 8.

10. The method of claim 9, wherein each code group of the DC control conversion table has as much codewords as a source word can correspond to pairs of codewords, each pair of codewords has opposite INV characteristics and is selectable.

11. The method of claim 10, wherein among the groups of the DC control conversion code table, a group having a lesser number of codewords than the minimum number of needed codewords takes surplus codewords from a group having a greater number of codewords than the minimum number of codewords, so as to have equal to or greater than the minimum number of codewords.

12. The method of claim 8, wherein the auxiliary DC control conversion table having a group of codewords, each having a length of 15 bits, having from 9 to 10 EZs, and having at least one LZ, and codewords which are taken from surplus codewords of the first main conversion code group;

a group of codewords, each having a length of 15 bits, having from 9 to 10 EZs, and having at least one LZ, and codewords which are taken from surplus codewords of the second main conversion code group;

a group of codewords, each having a length of 15 bits, having from 9 to 10 EZs, and having no LZ, the surplus codewords of the third main conversion code group, and having 7 to 8 LZs, or having 0 to 8 EZs;

a group of codewords, each having a length of 15 bits, and having 9 or 10 EZs, the surplus codewords of the fourth main conversion code group, and having 3 to 8 LZs and 0 to 8 EZs.

13. The method of claim 12, wherein when the code stream pairs are a, b1, c and a, b2, c, respectively, and b1 and b2 are DC control codewords having opposite INV characteristics, codewords are allocated such that the INV characteristics of code streams after conversion are maintained to be opposite even if code changes of a, b1, b2, or c occur due to violation of the predetermined run length between a, and b1(b2) or b1(b2) and c.

14. An allocation method for allocating codewords generated for source words to be recording on a recording medium, the method comprising:

when a preceding codeword a and a following codeword b form a code stream X, allocating one of two selectable codewords b1 and b2 as codeword b, wherein codewords b1 and b2 have opposite INVs which are parameters indicating whether the number of '1s' contained in a codeword is an odd number or an even number; and

when the code stream of a and b1 is X1, and the code stream of a and b2 is X2, allocating codewords such that the INVs of X1 and X2 are maintained to be opposite when a or b1(b2) should be replaced by another codewords in compliance with a predetermined boundary condition given between codewords.

15. The method of claim 14, wherein when the predetermined boundary condition is that the number of continuous '0s' between codewords should be at least 2, and when the number of continuous '0s' from the Least Significant Bit (LSB) of the codeword a in the Most Significant Bit (MSB) direction is 0, and the number of continuous '0s' from the MSB of the codewords b1 or b2 in the LSB direction is 1, code changes of either the codeword a or b1(b2) occur to satisfy the boundary condition.

16. The method of claim 14, wherein when the number of continuous '0s' between the codewords a and b is 1 or 0,

the codeword a or b is changed such that the number of 0s forming the boundary is greater than 2 and less than 10.

17. The method of claim 16, wherein the codeword a of the code stream X1 and the codeword a of the code stream X2 are changed to other codewords such that the resulting codewords a of code streams X1 and X2 have the same INV value, and as a result, by the INVs of codewords b1 and b2 following the codewords a respectively, the INVs of the X1 and X2 become different.

18. An allocation method for allocating codewords of source words to be recording on a recording medium, the method comprising:

when a preceding codeword b and a following codeword c form a code stream Y, allocating one of two selectable codewords b1 and b2 as the codeword b, wherein codewords b1 and b2 have opposite INVs which are parameters indicating whether the number of '1s' contained in a codeword is an odd number or an even number; and

when the code stream of b1 and c is Y1, and the code stream of b2 and c is Y2, allocating codewords such that INVs of Y1 and Y2 are maintained to be opposite when the codeword b1, b2 or c should be replaced by another codeword in compliance with a predetermined boundary condition between codewords.

19. The method of claim 18, wherein when the predetermined boundary condition is that the number of continuous '0s' between codewords should be at least 2, and when the number of continuous '0s' from the Least Significant Bit (LSB) of the codeword c toward the Most Significant Bit (MSB) is 1, codeword b which does not satisfy the boundary condition and is xxxxxxxxxxx1001 or xxxxxxxxxx10001 appears in both b1 and b2.

20. The method of claim 18, wherein when the number of continuous '0s' between the codewords a and b is 1 or 0, the codeword a or b is changed such that the number 0s forming the boundary is greater than 2 and less than 10.

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FIG. 1

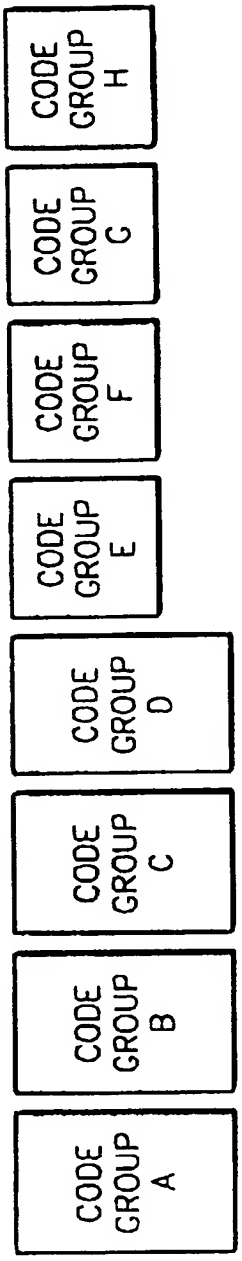


FIG. 2

NCG	1		2		3		4	
CODE GROUP CONTAINING CODEWORD INDICATED BY NCG	CONVERSION CODE GROUP	DC SUPPRESSION CODE GROUP FOR DC SUPPRESSION CONTROL WITH THE HELP OF MCG1	CONVERSION CODE GROUP	DC SUPPRESSION CODE GROUP FOR DC SUPPRESSION CONTROL WITH THE HELP OF MCG2	CONVERSION CODE GROUP	DC SUPPRESSION CODE GROUP FOR DC SUPPRESSION CONTROL WITH THE HELP OF DCG1	CONVERSION CODE GROUP	DC SUPPRESSION CODE GROUP FOR DC SUPPRESSION CONTROL WITH THE HELP OF DCG2
	MCG1	1st DSV CODE GROUP	MCG2	2nd DSV CODE GROUP	DCG1	3rd DSV CODE GROUP	DCG2	4th DSV CODE GROUP
CHARACTERISTIC	LZ=2~9	LZ=2~9	LZ=0~1	LZ=0~1	b15 (MSB)=b3=0		b15 (MSB)=1 또는 b3=1	
METHOD FOR DUPUCATED CODE	CODEWROD OF EZ=2~5 REPEATEDLY OCCURS IN ALL KINDS OF CODE GROUPS							

FIG. 3

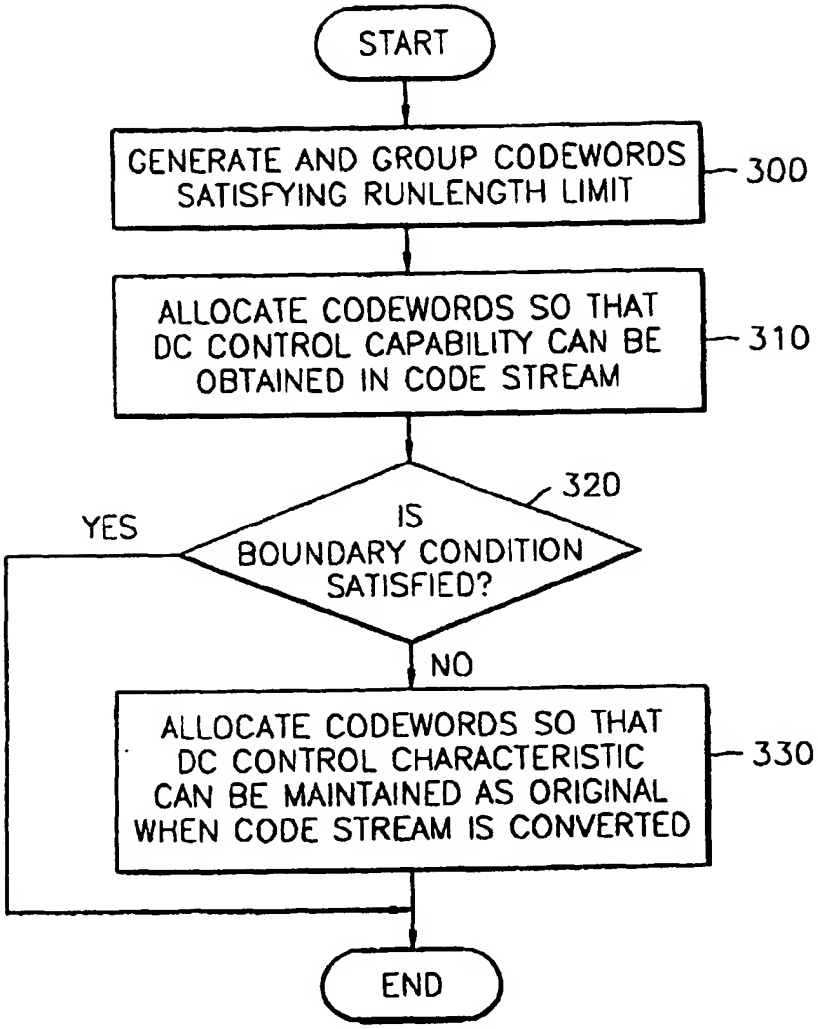


FIG. 4

	LZ (EZ)	NUMBER	ADD	NUMBER	DELETE	NUMBER	TOTAL NUMBER (DUPLICATED)
MCG1	$2 \leq LZ \leq 10$ $(0 \leq EZ \leq 8)$	177	$LZ=1$ $(0 \leq EZ \leq 8)$	83			260(4)
MCG2	$1 \leq LZ \leq 9$ $(0 \leq EZ \leq 8)$	257					257(1)
MCG3	$0 \leq LZ \leq 6$ $(0 \leq EZ \leq 8)$	360			$LZ=1$ $(0 \leq EZ \leq 8)$	83	277(21)
MCG4	$0 \leq LZ \leq 2$ $(0 \leq EZ \leq 8)$	262					262(6)

FIG. 5

	LZ (EZ)	NUMBER	ADD	NUMBER	DELETE	NUMBER	TOTAL NUMBER
DCG1	$2 \leq LZ \leq 10$ $(0 \leq EZ \leq 8)$	375	$LZ=1$ $(0 \leq EZ \leq 8)$	177			552
DCG2	$1 \leq LZ \leq 9$ $(0 \leq EZ \leq 8)$	546					546
DCG3	$0 \leq LZ \leq 6$ $(0 \leq EZ \leq 8)$	763			$LZ=1$ $(0 \leq EZ \leq 8)$	177	586
DCG4	$0 \leq LZ \leq 2$ $(0 \leq EZ \leq 8)$	556					556

FIG. 6

	LZ (EZ)	NUMBER	ADD	NUMBER		NUMBER	TOTAL NUMBER
ACG1	LZ≠0 (9≤EZ≤10)	5	SURPLUS CODE OF MCG1	4			9
ACG2	LZ≠0 (9≤EZ≤10)	5	SURPLUS CODE OF MCG2	1			6
ACG3	LZ≠1 (9≤EZ≤10)	5	SURPLUS CODE OF MCG3	21	7≤LZ≤8 (0≤EZ≤8)	15	41
ACG4	(9≤EZ≤10)	7	SURPLUS CODE OF MCG4	6	3≤LZ≤5 (0≤EZ≤8)	85	98

FIG. 7

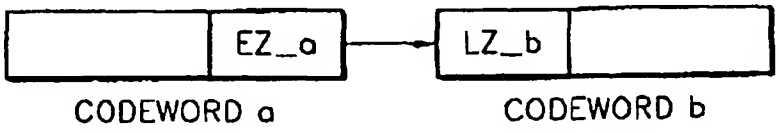
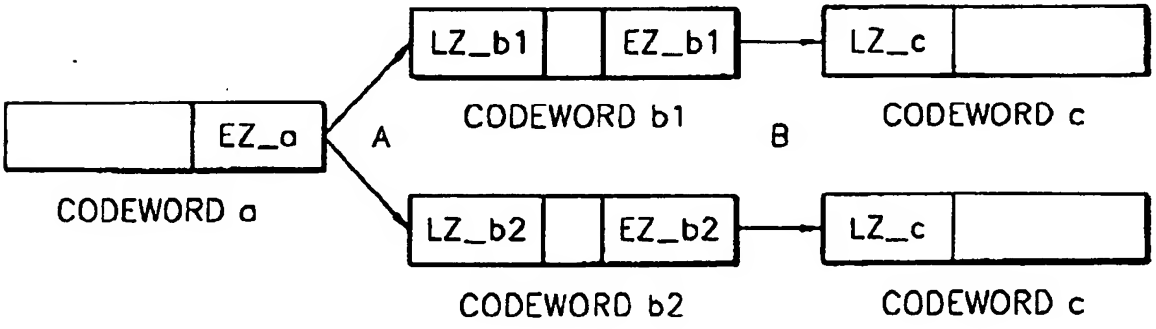


FIG. 8

CODEWORD a	CODEWORD b	CHANGE IN INV
xxxxxxxxx001001 (BEFORE CONVERSION) → xxxxxxxxx001000 (AFTER CONVERSION)	0100xxxxxxxxxx	CHANGE
xxxxxxxxx010001 (BEFORE CONVERSION) → xxxxxxxxx010000 (AFTER CONVERSION)		
xxxxxxxxx100001 (BEFORE CONVERSION) → xxxxxxxxx100100 (AFTER CONVERSION)		NO
~		
xxx100000000001 (BEFORE CONVERSION) → xxx100000000100 (AFTER CONVERSION)		

FIG. 9



DC CONTROL CODEWORD

FIG. 10

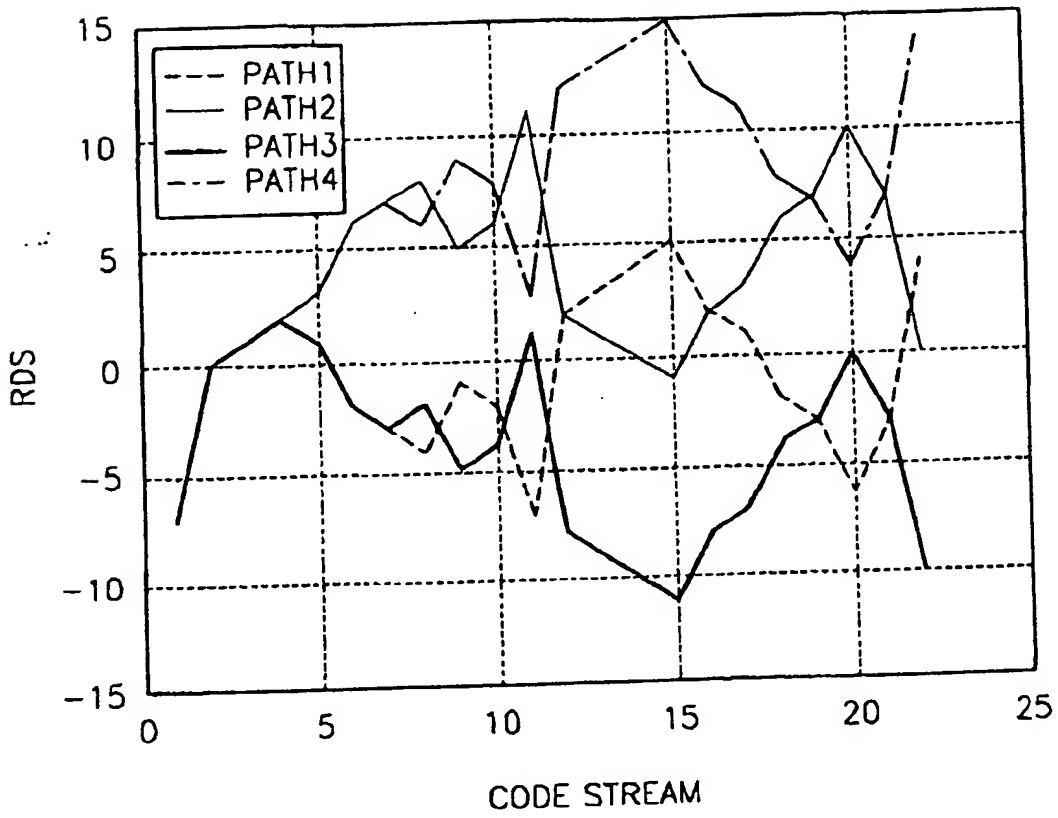


FIG. 11A

DATA SYMBOL	NCG1 Code Word MSB LSB	NCG	NCG2 Code Word MSB LSB	NCG	NCG3 Code Word MSB LSB	NCG	NCG4 Code Word MSB LSB	NCG
000	0001001000000000	4	0001001000000000	4	1001000000000001	1	1001000000000001	1
001	0000100100000000	4	0000100100000000	4	0010010000000001	1	0100100000000001	1
002	0010001001000000	4	0001001001000000	4	0000001000000001	1	0010010000000001	1
003	0100010010000000	4	0000001000100000	4	1000000000100001	1	1001001000000001	1
004	0100000100100000	4	0000000100010000	4	1000000010000001	1	1000100100000001	1
005	0100000001001001	1	0000000001001010	2	1001000000000010	2	1000010010000001	1
006	0100000100100000	3	0001000000001001	1	0010010000000010	2	1000001001000001	1
007	0100000100100001	1	0100100100001001	1	0010000000000010	2	1001000100000001	1
008	0100100000100010	2	0100010010000001	1	1001000000100010	2	1000100010000001	1
009	0100100100000001	1	0100001001001001	1	0010010000100010	2	1000010001000001	1
010	0000010010000000	4	0000100000001001	1	0001001000100010	2	0100100100000001	1
011	0000001001001000	4	0100100010001001	1	1000000000100010	2	0100010010000001	1
012	0000000100100000	3	0100010001001001	1	1000000001001010	2	0100001001001001	1
013	0000000010010000	3	0010010010000001	1	1001000000000100	3	1000000001001001	1
014	0000000001001000	3	0010001001001001	1	0010010000000100	3	1001000000000010	2
015	0000000000100100	3	0010001001001001	1	0001001000000100	3	0100100000000010	2
016	0000000000100010	2	0000010000000001	1	0001001001001001	3	0010000000000010	2
017	0000000001001001	1	0100100010001001	1	0000001001001001	3	0010010010000010	2
018	0000000000100100	3	0010010001001001	1	1000000100100100	3	1001001001000010	2
019	0100010001001001	1	0001001001001001	1	1000000010010000	3	1000100100000010	2
020	0100100100000001	1	0000001001001001	1	1000000001001000	3	1000010010000010	2
021	0100010001001001	1	0100100100000001	1	1000000100010000	3	1000001001001001	2
022	0100100100000001	1	0010010010000001	1	1000000010001000	3	1000000100100010	2
023	0100010001001001	1	0001001001001001	1	1000000001001001	3	1001001001000010	2
024	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
025	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
026	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
027	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
028	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
029	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
030	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
031	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
032	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
033	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
034	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
035	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
036	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
037	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
038	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
039	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
040	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
041	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
042	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
043	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
044	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
045	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
046	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
047	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
048	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
049	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
050	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
051	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
052	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
053	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
054	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
055	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
056	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2
057	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000010010000010	2
058	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000001001001001	2
059	0100010001001001	1	0100010010000001	1	1000000100100100	3	1000000100100010	2
060	0100100100000001	1	0100100100000001	1	1000001001001001	3	1000100100000010	2

FIG. 11B

DATA SYMBOL	NCG1 Code Word MSB LSB	NCG	NCG2 Code Word MSB LSB	NCG	NCG3 Code Word MSB LSB	NCG	NCG4 Code Word MSB LSB	NCG
061	0010010000001001	1	0000010010000010	2	0010000100000001	1	0100000010010000	3
062	0010010000000100	3	0000001001000010	2	0001000010000001	1	0100000001001000	3
063	0100100100000010	2	0000001001000010	2	0000100001000001	1	0100000001001000	3
064	0010010010000001	1	0000000100100010	2	0000010000100001	1	0010000100000000	4
065	0001001001000000	4	0100010000000010	2	1000010000000001	1	0100001000000000	4
066	0010010000000010	2	0010001000000010	2	0010000100000001	1	0010000100000000	4
067	0100100100000010	2	0001000100000010	2	0001000001000001	1	1001001000000000	4
068	0010001001000001	1	0000100001000010	2	0000100000100001	1	1000100100000000	4
069	0000001000000000	4	0000010001000010	2	1000001000000001	1	1000010010000000	4
070	0000000100100001	1	0000001000100010	2	0010000010000001	1	1000001001000000	4
071	0100001001000010	2	0100001000000010	2	0001000001000001	1	1001000100000000	4
072	0010000100100001	1	0010000100000010	2	1000000100000001	1	1000100010000000	4
073	0100000100100000	3	0001000010000010	2	0010000001000001	1	1000010001000000	4
074	0100000100100010	2	0000100001000010	2	1000100100000010	2	0100100100000000	4
075	0010000010010001	1	0000010000100010	2	1000010010000010	2	0100010010000000	4
076	0100000010000100	3	0100000000100010	2	1000001001000010	2	0100001001000000	4
077	0000100000000010	2	0100000001000010	2	1000000100100010	2	0100100001000000	4
078	0000010000000001	1	0010000000100010	2	0001000000000010	2	1000100001000000	4
079	0010000100100000	3	0100000010000010	2	1000100010000010	2	0100100010000000	4
080	0100000001000010	2	0010000001000010	2	1000010001000010	2	0100010001000000	4
081	0100000000100001	1	0001000000100010	2	1000001000100010	2	0010010010000000	4
082	0100000000000100	3	0100000100000010	2	0000100000000010	2	1001000000001001	1
083	0001001000000010	2	0010000010000010	2	1001000010000010	2	1000000000001001	1
084	0010000010010000	3	0001000001000010	2	1000100001000010	2	1000000000100001	1
085	0000000010010001	1	0000100000100010	2	1000010000100010	2	0100000000001001	1
086	0010000001001000	3	0000000010000010	2	0010010010000010	2	0100000000100001	1
087	0100001000000000	4	0100100000100010	2	0010000100100010	2	0010000000001001	1
088	0010000000100010	2	0010010000100010	2	0010000100100010	2	1001001000001001	1
089	0010000000010001	1	0000100100100010	2	0000010000000010	2	1000100100001001	1
090	0100000000001000	3	0000100100100010	2	0001001000000010	2	1000010010010001	1
091	0000100100000010	2	0000000100000010	2	0000100100000010	2	0010000001001001	1
092	0100001000000001	1	0100100001000010	2	0000010010000010	2	1000000100100001	1
093	0100100010010000	3	0100010000100010	2	0000001001000010	2	1000000010010001	1
094	0100100010000010	2	0010010000100010	2	1000100000000010	2	1000001000100001	1
095	0000010010000010	2	0010001000100010	2	0010001000000010	2	1000000100100001	1
096	0010001000000001	1	0001001001000010	2	0001000100000010	2	0100000010010001	1
097	0100100001001000	3	0001000100100010	2	0000100010000010	2	0100000001001001	1
098	0100100001000001	1	0000001000000010	2	0000010001000010	2	1001000010000001	1
099	0000010010000010	2	0100000000001000	3	0000001000100010	2	1000100001000001	1
100	0001000100000001	1	0100000000001000	3	1000010000000010	2	0100100010000001	1
101	0010010010010000	3	0010000000000100	3	0010000100000010	2	0100010001000001	1
102	0000000100000000	4	0100000000100000	3	0001000010000010	2	0010010010000001	1
103	0010010000100010	2	0010000000001000	3	0000100001000010	2	0010001001000001	1
104	0001001000001001	1	0001000000000100	3	0000010000100010	2	1001000000100001	1
105	0001001000000100	3	0100100100000100	3	1000000010000010	2	0100100001000001	1
106	0100010000100000	3	0100010010000100	3	0010000000100010	2	0010010001000001	1
107	0000100010000001	1	0100001001001000	3	1000100100100010	2	1000100000000001	1
108	0100001000001000	3	0010000000100000	3	1000001000000010	2	0100010000000001	1
109	0010000100000000	4	0001000000001000	3	0010000001000010	2	0010001000000001	1
110	0100000010000010	2	0000100000000100	3	0001000000100010	2	1000010000000001	1
111	0100000001000001	1	0100100000000100	3	1000001000000010	2	0100001000000001	1
112	0010000000000100	3	0010010000000100	3	0010000010000010	2	0010000100000001	1
113	0000010000100001	1	0001001000000100	3	0001000001000010	2	1000001000000001	1
114	0010010000100100	3	0000100100000100	3	0000100000100010	2	0100000100000001	1
115	0100010000100010	2	0000010010000100	3	0000010010010010	2	0010000010000001	1
116	0000001000100001	1	0000001001001000	3	1001000000100010	2	1000000010000001	1
117	0001001001001000	3	0100100000001000	3	1000100000100010	2	0100000001000001	1
118	0100010000100001	1	0100010000000100	3	0010010000100010	2	1000000100000001	1
119	0000000100010001	1	0010010000001000	3	0010001000100010	2	0100000010000001	1
120	0000100000100000	3	0010001000000100	3	0001001001000010	2	0010000001000001	1

FIG. 11C

DATA SYMBOL	NCG1 Code Word MSB LSB	NCG	NCG2 Code Word MSB LSB	NCG	NCG3 Code Word MSB LSB	NCG	NCG4 Code Word MSB LSB	NCG
121	0000000000100000	4	0001001000001000	3	0001000100010010	2	0100001001000010	2
122	0001001000010010	2	0001000100000100	3	0000001000000010	2	0100000100010010	2
123	0000100100001001	1	0000100100001000	3	1000000000001000	3	1001000010000010	2
124	0000100100000100	3	0000100001000100	3	1000000000010000	3	1000100001000010	2
125	0100000100000100	3	0000001001001000	3	0010000000000100	3	1000010000100010	2
126	0001000001000000	4	0000010001001000	3	1000100100000100	3	0100100010000010	2
127	0010000001000010	2	0100000100100000	3	1000010010001000	3	0100010001000010	2
128	0010000000100001	1	0100000010010000	3	1000001001001000	3	0100001000100010	2
129	0100000000100000	3	0100000001001000	3	0010000000010000	3	0010010010000010	2
130	0000010000010000	3	0100001001000000	3	0001000000000100	3	0010001001000010	2
131	0100001000100010	2	0100000100010000	3	1000100100010000	3	0010000100100010	2
132	0000001000000100	3	0100000010000100	3	1000100010000100	3	0010010000000010	2
133	0100001000010001	1	0010000100100000	3	1000001001001000	3	1000100000000010	2
134	0100100100010000	3	0010000010010000	3	1000010001001000	3	0100010000000010	2
135	0000000010000000	4	0010000001001000	3	0010000000100000	3	0010001000000010	2
136	0000100100100010	2	0100010000100000	3	0001000000010000	3	1000010000000010	2
137	0000010010010001	1	0100001000010000	3	0000100000000100	3	0100001000000010	2
138	0000010010000100	3	0100000100001000	3	0000100100000100	3	0010000100000010	2
139	0001000000100010	2	0010001000100000	3	0000010010001000	3	0010000000100010	2
140	0001000000001001	1	0010000100010000	3	0000001001001000	3	1000100100100010	2
141	0010000000010000	3	0010000010000100	3	1001000000010000	3	1000000100000010	2
142	0010010010000010	2	0001000100100000	3	1000100000000100	3	0100000010000010	2
143	0010010000100001	1	0001000010010000	3	0010010000010000	3	0010000001000010	2
144	0010001000100000	3	0001000001001000	3	0010001000000100	3	1001000100100010	2
145	0000000100100010	2	0100100000100000	3	0001001000001000	3	1000001000000010	2
146	0100010010010001	1	0100010000010000	3	0001001000000100	3	0100100100100010	2
147	0001000000000100	3	0100001000000100	3	0000100100010000	3	0100000100000010	2
148	0010001001000010	2	0010010000100000	3	0000100010000100	3	0010000010000010	2
149	0010001000100001	1	0010001000010000	3	0000010010001000	3	0010001000100010	2
150	0010000100010000	3	0010000100000100	3	0000010001000100	3	1001000001000010	2
151	0100001000000001	1	0001001000100000	3	1000000100000100	3	1000100000100010	2
152	0100100100000100	3	0001000100010000	3	0010000100100000	3	0100100001000010	2
153	0010000100100010	2	0001000001000100	3	0010000010010000	3	0100010000100010	2
154	0010000100010001	1	0000100100100000	3	0010000000100100	3	0010010000100010	2
155	0010000010000100	3	0000100010010000	3	1000100000100000	3	0010001000100010	2
156	0000100001000000	4	0000100000100100	3	1000010000001000	3	1000001001001000	3
157	0100000100000010	2	0000000100100000	3	1000001000000100	3	1000010001001000	3
158	0100000010000001	1	0000000010010000	3	0010001000100000	3	0100100100000100	3
159	0100000000100000	4	0000000000100100	3	0010000100010000	3	0100010010000100	3
160	0001000100100000	3	0000001000100000	3	0010000010000100	3	0100001001001000	3
161	0000001001001000	3	0000000100010000	3	0001000100100000	3	0010000000100000	3
162	0001001001000010	1	0000000010001000	3	0001000010010000	3	0100100000000100	3
163	0001000010010000	3	0000010000100000	3	0001000000100100	3	0010010000000100	3
164	0100010000000010	2	0000001000010000	3	1001000000100000	3	1001000000001000	3
165	0010000010000010	2	0000000100001000	3	1000100000001000	3	1000100000000100	3
166	0010000100000001	1	0100100100100000	3	1000010000000100	3	0100100000001000	3
167	0010000001000001	1	0100100001001000	3	0010010000100000	3	0100010000000100	3
168	0100100001000100	3	0100100000100100	3	0010001000001000	3	0010010000001000	3
169	0100010010000100	3	0010010010010000	3	0010000100000100	3	0010001000000100	3
170	0000000010000001	1	0010010000100100	3	0001001000100000	3	1000010000100000	3
171	0001000001001000	3	0001001001001000	3	0001000100010000	3	1000001000001000	3
172	0100100000010000	3	0000100000100000	3	0001000010000100	3	1000000100000100	3
173	0100100000100000	3	0000010000010000	3	0000100100100000	3	0100001001000000	3
174	0010001000000010	2	0000001000001000	3	0000100010010000	3	0100000100010000	3
175	0001000001000010	2	0100100100010000	3	0000100000100100	3	0100000010000100	3
176	0001000010000001	1	0100100010000100	3	0000010000100000	3	0010000100100000	3
177	0001000000100001	1	0100001001001000	3	0000001000001000	3	0010000010010000	3
178	0100010010010000	3	0100010000100100	3	1001000001001000	3	0010000000100100	3
179	0100001001001000	3	0010010010001000	3	1001000001001000	3	1000100000100000	3
180	0100010000000100	3	0010000100100100	3	0010010010010000	3	1000010000001000	3

FIG. 11D

DATA SYMBOL	MCG1 Code Word MSB LSB	NCG	MCG2 Code Word MSB LSB	NCG	MCG3 Code Word MSB LSB	NCG	MCG4 Code Word MSB LSB	NCG
181	0001000100000010	2	0001000000010000	3	0010010000100100	3	1000001000000100	3
182	0000100000100001	1	0000100000001000	3	0001001001001000	3	0100010000010000	3
183	0100010000100100	3	0000010000000100	3	0000100000010000	3	0100001000001000	3
184	0000010000000010	2	0100000001000000	4	0000010000001000	3	0100000100000100	3
185	0000000100000010	2	0000000001000000	4	0000001000000100	3	0010001000100000	3
186	0001000100100001	1	0000000010000000	4	1001000010000100	3	0010000100001000	3
187	0100100000100001	1	0100100100000000	4	1000100010010000	3	0010000010000100	3
188	0100010000001000	3	0100001001000000	4	1000100010001000	3	1001000000100000	3
189	0000100010000010	2	0100000100100000	4	1000100001001000	3	1000100000001000	3
190	0001000010010001	1	0100100010000000	4	0010010010000100	3	1000010000000100	3
191	0100001000000100	3	0100010001000000	4	0010001001001000	3	0100100000100000	3
192	0000010000100010	2	0010010010000000	4	0001000000100000	3	0100010000001000	3
193	0000100000100100	2	0010001001000000	4	0000100000001000	3	0100001000000100	3
194	0000010000100001	1	0100100000100000	4	0000010000000100	3	0010010000100000	3
195	0000100000010010	1	0010010001000000	4	1000000010000000	4	0010001000010000	3
196	0010010010000100	3	0000010010000000	4	1000100010000000	4	0010000100001000	3
197	0010000000100000	3	0000001001000000	4	1000010001000000	4	0100100010001000	3
198	0010010000100000	3	0010001000000000	4	1001000010000000	4	0100100000100100	3
199	0000001000100010	2	0001001000000000	4	1000100001000000	4	0010010010001000	3
200	0100001000000010	2	0000100010000000	4	0010010010000000	4	0010010000100100	3
201	0000001000010010	1	0000010001000000	4	0010000100100000	4	1001001000100000	3
202	0100100010010010	1	0100001000000000	4	1001000001000000	4	1001000100010000	3
203	0010001001001001	3	0010000100000000	4	0010010001000000	4	1001000010001000	3
204	0001000000001000	3	0001000010000000	4	0001001001000000	4	1000100010010000	3
205	0010000100000010	2	0000100001000000	4	0000001000000000	4	1000100010010000	3
206	0100000100000001	1	0100000100000000	4	0010001000000000	4	1000100001001000	3
207	0001000000100000	3	0010000010000000	4	0001000100000000	4	0100100010001000	3
208	0100100001001001	2	0001000001000000	4	0000100010000000	4	0100100010001000	3
209	0100010000100010	2	0100000010000000	4	0000010001000000	4	0100010010001000	3
210	0000001000000001	1	0010000001000000	4	0010000100000000	4	0100010001001000	3
211	0100010000010010	1	0100000100100100	1	0001000010000000	4	0100010001001000	3
212	0010001000010000	3	0100000010010010	1	0000100001000000	4	0010001001001000	3
213	0010010000010000	3	0100001000100100	1	1000001000000000	4	0010001001001000	3
214	0001000010000010	2	0100000100100100	1	0010000010000000	4	1000000100000000	4
215	0010010010010010	1	0010000100100100	1	0001000001000000	4	1000000010000000	4
216	0010000010000010	1	0010000010010010	1	0000100000100000	4	0100000001000000	4
217	0000100000010000	3	0100010000100100	1	1000000100000000	4	0010001001000000	4
218	0000100000000100	3	0100001000010010	1	0010000001000000	4	0010000100000000	4
219	0000100000100010	2	0010001000100100	1	1000001000010010	1	0100100000100000	4
220	0001000000100001	1	0010000100100100	1	1000001000010010	1	0010010001000000	4
221	0000100000010001	1	0001000100100100	1	0010000100100100	1	0010000100000000	4
222	0000010000000100	3	0001000010010010	1	0010000010010010	1	0100000100000000	4
223	0010000100000100	3	0100000000010010	1	0010000100100100	1	0010000010000000	4
224	0000010000010010	1	0100000000100100	1	0010000100100100	1	0100000001000000	4
225	0100000100000000	4	0010000000010010	1	0010000100100100	1	0010000001000000	4
226	0010010000100010	2	0010000000100100	1	0001000100100100	1	1000010000100100	1
227	0010001000100010	2	0001000000010010	1	0001000010010010	1	1000001000010010	1
228	0010010000100010	1	0100100100100100	1	1000000000010010	1	0100001000100100	1
229	0010001000010010	1	0100010010010010	1	1000000000100100	1	0100000100100100	1
230	0001001000100000	3	0001000000100100	1	0010000000010010	1	0010000100100100	1
231	0010001000000100	3	0000100000010010	1	1000010010010010	1	0010000010010010	1
232	0001000100100000	3	0100100000100100	1	1000001001001001	1	1000100000100100	1
233	0010000010000000	4	0010010000010010	1	0010000000100100	1	1000001000010010	1
234	0001000010000100	3	0001001000010010	1	0001000000010010	1	0100010000100100	1
235	0000100100100000	3	0000100100100100	1	1000100100100100	1	0100001000010010	1
236	0001000001000000	4	0000010010010010	1	1000100010010010	1	0010001000100100	1
237	0000100010010000	3	0100100000100100	1	1000100001001001	1	0010000100100100	1
238	0100000010000000	4	0100001000010010	1	0000100000010010	1	0010000010010010	1
239	0001001001000010	2	0010010000100100	1	0000100100100100	1	1000100100100100	1
240	0001000100100010	2	0010001000010010	1	0000010010010010	1	1000100010010010	1

FIG. 11E

DATA SYMBOL	MCG1 Code Word MSB LSB	MCG1 NCG	MCG2 Code Word MSB LSB	MCG2 NCG	MCG3 Code Word MSB LSB	MCG3 NCG	MCG4 Code Word MSB LSB	MCG4 NCG
241	000100100010001	1	000100100010001	1	100100000010001	1	010010010001001	1
242	000100010001001	1	000100010001001	1	100010000001001	1	010001001001001	1
243	000010000100100	3	000010010010001	1	001001000010001	1	010010000001001	1
244	000100100001000	3	000010001001001	1	001000100001001	1	001001000001001	1
245	001000000100000	4	000000010010001	1	000100100010001	1	100100000010001	1
246	000010010010001	1	000000001001001	1	000100010001001	1	100010000001001	1
247	000000100000010	2	000000100010001	1	000010010010001	1	010010000010001	1
248	000010001001001	1	000000010001001	1	000010001001001	1	010001000001001	1
249	000100010000100	3	000001000010001	1	000000100010001	1	001001000010001	1
250	000001000010010	2	000000100001001	1	000001000010001	1	001000100001001	1
251	000010010001000	3	010010010010001	1	000000100001001	1	100100010010001	1
252	000010001000100	3	010010001001001	1	100100001001001	1	100100001001001	1
253	000001001001000	3	001001001001001	1	001001001001001	1	010010010010001	1
254	000000010000001	1	000010000010001	1	000010000010001	1	010010001001001	1
255	000001000100100	3	000001000001001	1	000001000001001	1	001001001001001	1

FIG. 12A

DATA SYMBOL	DCG11 Code Word MSB LSB	NCG	DCG12 Code Word MSB LSB	NCG	DCG21 Code Word MSB LSB	NCG	DCG22 Code Word MSB LSB	NCG
000	0010010010000001	1	0010010000000001	1	0100100100000001	1	0010010000000001	1
001	0010001001000001	1	0001001000000001	1	0100010010000001	1	0001001000000001	1
002	0010000100100001	1	0000100100000001	1	0100001001000001	1	0000100100000001	1
003	0010000010010001	1	0000010010000001	1	0100000100100001	1	0000010010000001	1
004	0000010000000001	1	0000001001000001	1	0100000010010001	1	0000001001000001	1
005	0010010001000001	1	0000000100100001	1	0100100001000001	1	0000000100100001	1
006	0010001000100001	1	0000000010010001	1	0100010000100001	1	0000000010010001	1
007	0010000100010001	1	0010001000000001	1	0100001000100001	1	0010001000000001	1
008	0001001001000001	1	0001000100000001	1	0100000100010001	1	0001000100000001	1
009	0001000100100001	1	0000100010000001	1	0010010010000001	1	0000100010000001	1
010	0001000010010001	1	0000010001000001	1	0010001001000001	1	0000010001000001	1
011	0000001000000001	1	0000001000100001	1	0010000100100001	1	0000001000100001	1
012	0010010000100001	1	0000000100010001	1	0010000100010001	1	0000000100010001	1
013	0010001000100001	1	0010000100000001	1	0000010000000001	1	0000000100010001	1
014	0001001000100001	1	0001000010000001	1	0100100001000001	1	0100001000000001	1
015	0001000100010001	1	0000100001000001	1	0100010000100001	1	0001000010000001	1
016	0000100100100001	1	0000010000100001	1	0100001000010001	1	0000100001000001	1
017	0000100010010001	1	0000001000010001	1	0010010001000001	1	0000010000100001	1
018	0000000100000001	1	0010010010010001	1	0010001000100001	1	0000001000010001	1
019	0000000000100001	1	0010000100000001	1	0010000100010001	1	0100100100100001	1
020	0000000001000001	1	0001000001000001	1	0001001001000001	1	0100100010010001	1
021	0010010000010001	1	0000100000100001	1	0001000100100001	1	0100000100000001	1
022	0001001000010001	1	0000010000010001	1	0000010000000001	1	0010010010010001	1
023	0000100100010001	1	0010000000010001	1	0100100000100001	1	0010000100000001	1
024	0000010010010001	1	0010000001000001	1	0100010000010001	1	0001000010000001	1
025	0000000100000001	1	0001000000010001	1	0100001000001001	1	0000100000100001	1
026	0000100000000010	2	0010010000000010	2	0010010000100001	1	0000010000010001	1
027	0010010010000010	2	0001001000000010	2	0010001000010001	1	0000001000010001	1
028	0010001001000010	2	0000100100000010	2	0001001000100001	1	0100100100100001	1
029	0010000100100010	2	0000010010000010	2	0001000100010001	1	0100010010010001	1
030	0010000010010010	2	0000001001000010	2	0000100100100001	1	0100000100000001	1
031	0010000001001001	2	0000000100100010	2	0000100010010001	1	0010000010000001	1
032	0000010000000010	2	0000000010010010	2	0000001000000001	1	0001000001000001	1
033	0010010001000010	2	0000000001001001	2	0000000100100001	1	0000100000100001	1
034	0010001000100010	2	0010001000000010	2	0100100000010001	1	0100010010010001	1
035	0010000100010010	2	0001001000000010	2	0010010000010001	1	0100000000100001	1
036	0010000010001001	2	0000100010000010	2	0001001000010001	1	0010000001000001	1
037	0001001001000010	2	0000010001000010	2	0000100100010001	1	0100000001000001	1
038	0001000100100010	2	0000001001001001	2	0000010010010001	1	0010000000100001	1
039	0001000010010010	2	0000000100010010	2	0000000100000001	1	0001000000100001	1
040	0001000001001001	2	0000000010010010	2	0100100100000010	2	0100100000000010	2
041	0000001000000010	2	0010000100000010	2	0100010010000010	2	0010010000000010	2
042	0000000000100010	2	0001000010000010	2	0100001001000010	2	0001001000000010	2
043	0010010000010010	2	0000100001000010	2	0100000100100010	2	0000100100000010	2
044	0001001000001001	2	0000010000100010	2	0100000010010010	2	0000010010000010	2
045	0000100100010010	2	0000001000010010	2	0100000001001001	2	0000001001000010	2
046	0000010010010010	2	0000000100001001	2	0001000000000010	2	0000000100100010	2
047	0000001001001001	2	0010010010010010	2	0100100010000010	2	0000000010010010	2
048	0000000010000010	2	0010010001001001	2	0100010001000010	2	0100010000000010	2
049	0010010000100010	2	0010000100000010	2	0100001000100010	2	0010001000000010	2
050	0010001000010010	2	0001001001001001	2	0100000100010010	2	0001001000000010	2
051	0001001000100010	2	0001000001000010	2	0100000010010010	2	0000100100000010	2
052	0001000100010010	2	0000100000100010	2	0010010010000010	2	0000010010000010	2
053	0000100100100010	2	0000010000100010	2	0010001001000010	2	0000001000100010	2
054	0000100010010010	2	0000001000010010	2	0010000100100010	2	0000000100010010	2
055	0000010010010010	2	0010000000010010	2	0010000001001001	2	0000000010010010	2
056	0000010001001001	2	0010000000100010	2	0010000001001001	2	0100001000000010	2
057	0000000010000010	2	0001000000010010	2	0000010000000010	2	0010001000000010	2
058	0010010000100010	2	0010000000100010	2	0100100001000010	2	0001000100000010	2
059	0010001000010010	2	0001000000100010	2	0100010000100010	2	0000100010000010	2
060	0010000100001001	2	0000100000010010	2	0100001000010010	2	0000010000100010	2

FIG. 12B

DATA SYMBOL	DCG11 Code Word MSB LSB	NCG	DCG12 Code Word MSB LSB	NCG	DCG21 Code Word MSB LSB	NCG	DCG22 Code Word MSB LSB	NCG
061	0001001000100000	2	0010010010001010	2	0100000100001010	2	0000010000100010	2
062	0001000100010010	2	0010001001010010	2	0010010000100010	2	0000001000010010	2
063	0001000010001010	2	0010000001000010	2	0010001000100010	2	0000000100001010	2
064	0000100100100010	2	0001000000100010	2	0010000100010010	2	0100100100100010	2
065	0000100010010010	2	0000100000010010	2	0010000010001010	2	0100100010010010	2
066	0000100000100100	2	0000010000001010	2	0001001001000010	2	0100100000100100	2
067	0010000000001000	3	0010010000000100	3	0001000100100010	2	0100000100000010	2
068	0001000000000100	3	0001001000000100	3	0001000010010010	2	0010010010010010	2
069	0010000000010000	3	0000100100000100	3	0001000001001010	2	0010010001001010	2
070	0001000000001000	3	0000010010000100	3	0000001000000010	2	0010000010000010	2
071	0000100000000100	3	0000001001000100	3	0100100000010010	2	0001001001001010	2
072	0010010010000100	3	0000000100100100	3	0010010000001010	2	0001000001000010	2
073	0010001001000100	3	0000000010010100	3	0001001000001010	2	0000100000100010	2
074	0010000100100100	3	0010010000001000	3	0000100100010010	2	0000010000100010	2
075	0010000010010010	3	0010001000000100	3	0000010010001010	2	0000001000010010	2
076	0001000000010000	3	0001001000001000	3	0000001001001010	2	0100000000010010	2
077	0000100000001000	3	0001000100000100	3	0000000010000010	2	0100000000100010	2
078	0000010000000100	3	0000100100001000	3	0100100000100010	2	0010000000010010	2
079	0000000001001000	3	0000100010000100	3	0100010000010010	2	0100000000100010	2
080	0000000000100100	3	0000010010001000	3	0010010000100010	2	0010000000100010	2
081	0000000010001000	3	0000010001000100	3	0010001000010010	2	0001000000010010	2
082	0000000001000100	3	0000001001001000	3	0001001000100010	2	0100100100010010	2
083	0000000000100100	3	0000001000100100	3	0001000100010010	2	0100010010010010	2
084	0000000100010000	3	0000000100100100	3	0000100100010010	2	0100001001001010	2
085	0000000010001000	3	0000000100010100	3	0000100010010010	2	0100000010000010	2
086	0000000001000100	3	0010010000001000	3	0000010010010010	2	0010000000100010	2
087	0010010001001000	3	0010001000001000	3	0000010001001010	2	0001000000100010	2
088	0010010000100100	3	0010000100000100	3	0000000010000010	2	0000100000010010	2
089	0010010000010100	3	0001001000001000	3	0100100000100010	2	0100100100010010	2
090	0001001001001000	3	0001000100000100	3	0100010000010010	2	0100100010010010	2
091	0001001000100100	3	0001000010000100	3	0100010000001010	2	0100010010010010	2
092	0001001000010100	3	0000100100001000	3	0010010000100010	2	0100001001001010	2
093	0000100100100100	3	0000100010000100	3	0010001000010010	2	0100000100000010	2
094	0000100100010100	3	0000100001000100	3	0010000100001010	2	0010010010010010	2
095	0000010010010100	3	0000100010000100	3	0001001000100010	2	0010001001001010	2
096	0000001000001000	3	0000100001000100	3	0001000100010010	2	0010000010000010	2
097	0000000100000100	3	0000100000100100	3	0001000010001010	2	0001000001000010	2
098	0000000010000100	3	0000010001001000	3	0000100100100010	2	0000100000100010	2
099	0010010010001000	3	0000010000100100	3	0000100010010010	2	0000010000010010	2
100	0010010001001000	3	0000010000010100	3	0100000000001000	3	0100100000000100	3
101	0010010000100100	3	0010000001001000	3	0010000000000100	3	0010010000000100	3
102	0010001001001000	3	0010000000100100	3	0001000000000100	3	0001001000000100	3
103	0010001000100100	3	0010000000010100	3	0100100100000100	3	0000100100000100	3
104	0010001000010100	3	0010000010001000	3	0100010010000100	3	0000010010000100	3
105	0001001001001000	3	0010000001001000	3	0100001001000100	3	0000001001000100	3
106	0001001000100100	3	0010000000100100	3	0100000100100100	3	0000000100100100	3
107	0001000100100100	3	0001000000100100	3	0100000010010010	3	0000000010010010	3
108	0001000100010100	3	0001000000100100	3	0010000000010010	3	0100100000001000	3
109	0000100100100100	3	0001000000010100	3	0001000000100100	3	0100010000000100	3
110	0000100010010100	3	0010000100010100	3	0000100000000100	3	0010010000001000	3
111	0000010000010100	3	0010000010001000	3	0100100100001000	3	0010001000000100	3
112	0000001000001000	3	0010000010000100	3	0100100010000100	3	0001001000001000	3
113	0000000100000100	3	0001000010010100	3	0100010010001000	3	0001000100000100	3
114	0010010010001000	3	0001000001001000	3	0100010000100100	3	0000100100001000	3
115	0010010000100100	3	0001000000100100	3	0100001001001000	3	0000100010000100	3
116	0010001001001000	3	0000100001001000	3	0100001000100100	3	0000010010000100	3
117	0010001000100100	3	0000100000100100	3	0100000100100100	3	0000010001001000	3
118	0010000100100100	3	0000100000010100	3	0100000010010010	3	0000001001001000	3
119	0010000100010100	3	0010010010010010	3	0010010010000100	3	0000001000100100	3
120	0001001001000100	3	0010001000001000	3	0010001001000100	3	0000000100100100	3

FIG. 12C

DATA SYMBOL	DCG11 Code Word MSB LSB	NCG	DCG12 Code Word MSB LSB	NCG	DCG21 Code Word MSB LSB	NCG	DCG22 Code Word MSB LSB	NCG
121	0001000010010001 00	3	0010000100000100 00	3	0010000010010001 00	3	0000000010001001 00	3
122	0001000001001001 00	3	0010000010000010 00	3	0010000001001001 00	3	0100100000001000	3
123	0000100000001000	3	0001000100001000	3	0000100000001000	3	0100010000000100	3
124	0000010000000100	3	0001000010000100	3	0000010000000100	3	0100001000000010	3
125	0000001000000010	3	0001000001000010	3	0000010000000010	3	0010001000001000	3
126	0010000000100000	4	0000000000100000	4	0000000001001000	3	0010000100000100	3
127	0000010010000000	4	0000000001000000	4	0000000010001000	3	0010000010000010	3
128	0000001001000000	4	0010010010000000	4	0000000001000100	3	0001001000001000	3
129	0000000100100000	4	0010001001000000	4	0000000100001000	3	0001000100000100	3
130	0000000010010000	4	0010000100100000	4	0000000010000100	3	0001000010000010	3
131	0000100010000000	4	0010000010010000	4	0000000001000100	3	0000100100001000	3
132	0000010001000000	4	0010010001000000	4	0100100001001000	3	0000100010000100	3
133	0000001001000000	4	0010001001000000	4	0100100000100100	3	0000100001000010	3
134	0000000100100000	4	0010000100100000	4	0100100000010010	3	0000010010001000	3
135	0001000010000000	4	0001001001000000	4	0010010000100100	3	0000010001000100	3
136	0000100001000000	4	0001000100100000	4	0010010000010010	3	0000010000100010	3
137	0000010000100000	4	0001000010010000	4	0010010000001001	3	0000001001001000	3
138	0000001000010000	4	0010010000100000	4	0001001001001000	3	0000010000100100	3
139	0010010010010000	4	0010001000010000	4	0001001000100100	3	0100000010010000	3
140	0010000010000000	4	0001001000010000	4	0001001000001001	3	0100000001001000	3
141	0001000001000000	4	0001000100010000	4	0000100100100100	3	0100000000100100	3
142	0000100000100000	4	0000100100100000	4	0000100100010010	3	0100000000010010	3
143	0000010000010000	4	0000100010010000	4	0000010010010010	3	0100000001001000	3
144	0010000001000000	4	0010010000010000	4	0000001000001000	3	0100000000100100	3
145	0001000000100000	4	0001001000010000	4	0000000100000100	3	0100000000010010	3
146	0000100000010000	4	0000100100010000	4	0000000010000010	3	0010000001001000	3
147	0010000000100000	4	0000010010010000	4	0100100010010000	3	0010000000100100	3
148	0001000000010000	4	0000000010000000	4	0100100001001000	3	0010000000010010	3
149	0100000001001001	1	0100100001001001	1	0100100000100100	3	0100000100001000	3
150	0100000000100100	1	0100100000100100	1	0100010001001000	3	0100000010000100	3
151	0100000010001001	1	0100100010001001	1	0100100000100100	3	0100000001000010	3
152	0100000001001001	1	0100100001001001	1	0100010000010010	3	0010000010001000	3
153	0100000100001001	1	0100010001001001	1	0010010010001000	3	0010000001000100	3
154	0100000010001001	1	0100010000100100	1	0010010001001000	3	0010000000100010	3
155	0100100100100100	1	0100000000001001	1	0010010000100100	3	0001000001001000	3
156	0100001000001001	1	0100100100000100	1	0010001001001000	3	0001000000100100	3
157	0100000100000100	1	0100010010000100	1	0010001000100100	3	0001000000010010	3
158	0100100000001001	1	0100001001001001	1	0010001000010010	3	0100100100100100	3
159	0100100000001001	1	0100001001001001	1	0001001001001000	3	0100100100100100	3
160	0100010000001001	1	0100100100001001	1	0001001000100100	3	0100010010010010	3
161	0100010000001001	1	0100100010000100	1	0001000100100100	3	0100001000001000	3
162	0100001000001001	1	0100010010001001	1	0001000100010010	3	0100000100000100	3
163	0100100100000001	1	0100100000000001	1	0000100100100100	3	0100000010000100	3
164	0100010010000001	1	0100001000000001	1	0000100010010010	3	0010000100001000	3
165	0100001001000001	1	0100100100100001	1	0000010000001000	3	0010000010001000	3
166	0100001001000001	1	0100100010010001	1	0000001000001000	3	0010000001000100	3
167	0100000100100001	1	0100000100000001	1	0000001000000100	3	0001000010001000	3
168	0100100010000001	1	0100100100100001	1	0100100100001000	3	0001000001001000	3
169	0100010001000001	1	0100010010010001	1	0100100010001000	3	0001000000100100	3
170	0100001000100001	1	0100000010000001	1	0100100001000100	3	0001000000010010	3
171	0100000100010001	1	0100000000100001	1	0100010010001000	3	0000100000100100	3
172	0100100001000001	1	0100000001000001	1	0100100010001000	3	0000100000010010	3
173	0100100000100001	1	0100000001000001	1	0100010000100100	3	0100100100100100	3
174	0100100100000010	2	0100100000000010	2	0100001001001000	3	0100100010010010	3
175	0100010010000010	2	0100010000000010	2	0100001000100100	3	0100010000001000	3
176	0100001001000010	2	0100001000000010	2	0100001000010010	3	0100001000000100	3
177	0100000100100010	2	0100100100100010	2	0010010001001000	3	0100000100000010	3
178	0100000010010010	2	0100100010010010	2	0010010000100100	3	0010010010010010	3
179	0100000001001001	2	0100100001001001	2	0010001001000100	3	0010001000001000	3
180	0100100010000010	2	0100000100000010	2	0010001000100100	3	0010000100000100	3

FIG. 12D

DATA SYMBOL	DCG11 Code Word MSB LSB	NCG	DCG12 Code Word MSB LSB	NCG	DCG21 Code Word MSB LSB	NCG	DCG22 Code Word MSB LSB	NCG
181	0100010001000010	2	0100000000010010	2	0010000100100100	3	0010000010000100	3
182	0100001000100010	2	0100000000100010	2	0010000100010010	3	0001000100001000	3
183	0100000100010010	2	0100000000100010	2	0001001001000100	3	0001000010000100	3
184	0100000010001001	2	0100100100010010	2	0001000100100100	3	0001000001000100	3
185	0100100001000010	2	0100010010001001	2	0001000010010010	3	0000100001000100	3
186	0100010000100010	2	0100001001001001	2	0000100000010000	3	0000100001000100	3
187	0100100000001001	2	0100000001000010	2	0000010000001000	3	0000100001000100	3
188	0100100000100010	2	0100100100010010	2	0000001000000100	3	0000010001001000	3
189	0100010000001001	2	0100100100010010	2	0100000000100000	4	0100001001000000	4
190	0100100000100010	2	0100010010001001	2	0100000001000000	4	0100000100100000	4
191	0100010000100010	2	0100010010001001	2	0010000000100000	4	0100000010010000	4
192	0100001000001001	2	0100000100000010	2	0000001001000000	4	0100001000100000	4
193	0100000000010000	3	0100100000000100	3	0000000100100000	4	0100001000100000	4
194	0100100100000100	3	0100100000001000	3	0000000010010000	4	0100000100100000	4
195	0100010010000100	3	0100010000000100	3	0000010001000000	4	0010001001000000	4
196	0100001001000100	3	0100100000010000	3	0000001000100000	4	0010000100100000	4
197	0100000100100100	3	0100010000001000	3	0000000100010000	4	0010000010010000	4
198	0100000010010010	3	0100001000000100	3	0000100001000000	4	0100100001000000	4
199	0100100100001000	3	0100000001001000	3	0000010000100000	4	0100010000100000	4
200	0100100010000100	3	0100000000100100	3	0000001000010000	4	0100001000010000	4
201	0100100001001000	3	0100000000010010	3	0100100100100000	4	0010010001000000	4
202	0100100000100100	3	0100000100100000	3	0100100010010000	4	0010001000100000	4
203	0100100000010010	3	0100000001001000	3	0010010010010000	4	0010000100010000	4
204	0100100010001000	3	0100000000100100	3	0001000001000000	4	0001001001000000	4
205	0100100001001000	3	0100000100010000	3	0000100000100000	4	0001000100100000	4
206	0100100000100100	3	0100000010001000	3	0000010000010000	4	0000100001000000	4
207	0100010001001000	3	0100000001001000	3	0100100100010000	4	0100100000100000	4
208	0100010000100100	3	0100100100100100	3	0100010010010000	4	0100010000010000	4
209	0100010000010010	3	0100100100010010	3	0010000001000000	4	0010010000100000	4
210	0100100100001000	3	0100010010001001	3	0001000000100000	4	0001000100100000	4
211	0100100010000100	3	0100001000001001	3	0000100000010000	4	0000100100100000	4
212	0100100001000100	3	0100000100000100	3	0100000001000000	4	0000100010010000	4
213	0100010010001000	3	0100000010000100	3	0010000000100000	4	0000100100100000	4
214	0100010001001000	3	0100100100100100	3	0001000000010000	4	0000100010010000	4
215	0100010000100100	3	0100100010010000	3	0100000001001001	1	0100000000010001	1
216	0100001001001000	3	0100010000001000	3	0100000000100100	1	0010000000001001	1
217	0100001000100100	3	0100001000000100	3	0100000100010001	1	0010000000010001	1
218	0100001000100100	3	0100001000000100	3	0100000001000100	1	0001000000001001	1
219	0100000000100000	4	0100010010000000	4	0010000001001001	1	0100100100001001	1
220	0100000000100000	4	0100001001000000	4	0010000000100100	1	0100010010001001	1
221	0100100100100000	4	0100000100100000	4	0100000100010001	1	0100001001001001	1
222	0100100010010000	4	0100000010010000	4	0100000010000100	1	0100000100100001	1
223	0100100100100000	4	0100100100000000	4	0010000100010001	1	0001000000010001	1
224	0100010010010000	4	0100010001000000	4	0010000001001001	1	0000100000001001	1
225	0100000100100000	4	0100001000100000	4	0001000001001001	1	0100100100010001	1
226	0100000010010000	4	0100000100010000	4	0001000000100100	1	0100100010001001	1
227	0010000001001001	1	0000000010010001	1	0100100100100100	1	0100010010001001	1
228	0010000000100100	1	0000000001001001	1	0100001000001001	1	0100010001001001	1
229	0010000100010001	1	0000000100010001	1	0100000100000100	1	0100001001001001	1
230	0010000001001001	1	0000000001001001	1	0010000100001001	1	0100010001001001	1
231	0001000001001001	1	0000000100010001	1	0010000010000100	1	0010010010001001	1
232	0001000000100100	1	0000000100010001	1	0001000001001001	1	0010001001001001	1
233	0010000100010001	1	0010010001001001	1	0001000001001001	1	0010000100100100	1
234	0010000100010001	1	0010010000100100	1	0000100001001001	1	0000100000010001	1
235	0001000100010001	1	0001001001001001	1	0000100000100100	1	0000010000001001	1
236	0001000001001001	1	0001001000100100	1	0100100000001001	1	0000000010010001	1
237	0000100001001001	1	0000100100100100	1	0010010000001001	1	0000000100010001	1
238	0000100000100100	1	0000001000001001	1	0001001000001001	1	0000000010001001	1
239	0010010000001001	1	0000000100001001	1	0000100100001001	1	0000000100010001	1
240	0001001000001001	1	0010010010001001	1	0000010010000100	1	0000000010001001	1

FIG. 12E

DATA SYMBOL	DCG11		DCG12		DCG21		DCG22	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
241	0000100100000001	1	0010010000100001	1	0000001001000001	1	0100100001001000	1
242	0000010010000001	1	0010000100100001	1	0000000010010001	1	0100100000100100	1
243	0001000010000001	1	0010001000100100	1	0100100000001000	1	0010010000100000	1
244	0000100001000001	1	0001001000010001	1	0100010000000100	1	0010010000100100	1
245	0000100001000100	1	0001000100100100	1	0010010000001000	1	0001001001000100	1
246	0000010001001000	1	0000010000001000	1	0010001000000100	1	0001001000100100	1
247	0000010000100100	1	0000001000000100	1	0001001000001000	1	0000100100100100	1
248	0001000100000100	1	0010000000000100	1	0001000100000100	1	0000001000001000	1
249	0000100100001000	1	0010000000001000	1	0000100100001000	1	0000000100000100	1
250	0000100010000100	1	0001000000000100	1	0000100010000100	1	0100100010001000	1
251	0000010010001000	1	0001000000001000	1	0000010010001000	1	0100100001000100	1
252	0000010001000100	1	0000100000000100	1	0000010001000100	1	0100010001001000	1
253	0000001001001000	1	0010010000001000	1	0000001001001000	1	0100010000100100	1
254	0000001000100100	1	0010001001000100	1	0000001000100100	1	0010010001000100	1
255	0010001000001000	1	0010000100100100	1	0100010000001000	1	0010010001000100	1

FIG. 12F

DATA SYMBOL	DCG31 Code Word MSB LSB	NCG	DCG32 Code Word MSB LSB	NCG	DCG41 Code Word MSB LSB	NCG	DCG42 Code Word MSB LSB	NCG
000	1001001000000001	1	0010010000000001	1	1001001000000001	1	0010010000000001	1
001	1000100100000001	1	0001001000000001	1	1000100100000001	1	0100010000000001	1
002	1000010010000001	1	0000100100000001	1	1000010010000001	1	0010001000000001	1
003	1000001001000001	1	0000010010000001	1	1000001001000001	1	1000010000000001	1
004	1000000100100001	1	0000001001000001	1	1000000100100001	1	0100001000000001	1
005	1000000010010001	1	0010001000000001	1	1000000010010001	1	0010000100000001	1
006	1001000100000001	1	0001000100000001	1	1001000100000001	1	1001001001000001	1
007	1000100010000001	1	0000100010000001	1	1000100010000001	1	1001000100100001	1
008	1000010001000001	1	0000010001000001	1	1000010001000001	1	1001000010010001	1
009	1000001000100001	1	0000001000100001	1	1000001000100001	1	1000001000000001	1
010	1000000100010001	1	1000010000000001	1	1000000100010001	1	0100100100100001	1
011	1001000010000001	1	0010000100000001	1	0100100100000001	1	0100100010010001	1
012	1000100001000001	1	0001000010000001	1	0100010010000001	1	0100000100000001	1
013	1000010000100001	1	0000100001000001	1	0100001001000001	1	0010010010010001	1
014	1000001000010001	1	0000010000100001	1	0100000100100001	1	0010000010000001	1
015	0010010010000001	1	0000001000010001	1	0100000010010001	1	1001001000100001	1
016	0010001001000001	1	1001001001000001	1	1001000010000001	1	1001000100010001	1
017	0010000100100001	1	1001000100100001	1	1000100001000001	1	1000100100100001	1
018	0010000010010001	1	1001000010010001	1	1000010000100001	1	1000100010010001	1
019	0000010000000001	1	1000001000000001	1	1000001000010001	1	1000000100000001	1
020	1001000001000001	1	0010010010010001	1	0100100010000001	1	0100100100010001	1
021	1000100000100001	1	0010000010000001	1	0100010001000001	1	0100010010010001	1
022	1000010000010001	1	0001000001000001	1	0100001000100001	1	0100000100000001	1
023	0010010001000001	1	0000100000100001	1	0100000100010001	1	0010000001000001	1
024	0010001000100001	1	0000010000010001	1	0010010010000001	1	1000000000100001	1
025	0010000100010001	1	1001001000100001	1	0010001001000001	1	1000000001000001	1
026	0001001001000001	1	1001000100010001	1	0010000100100001	1	0100000000100001	1
027	0001000100100001	1	1000100100100001	1	0010000010010001	1	1000000001000001	1
028	0001000010010001	1	1000100010010001	1	1001000001000001	1	0100000000100001	1
029	0000001000000001	1	1000001000000001	1	1000100000100001	1	0010000000010001	1
030	1001000000100001	1	0010000001000001	1	1000010000010001	1	1001001000010001	1
031	1000100000010001	1	0001000000100001	1	0100100001000001	1	1000100100100001	1
032	0010010000100001	1	0000100000010001	1	0100010000100001	1	1000010010010001	1
033	0010001000010001	1	1000000000010001	1	1001000000010001	1	1000000100000001	1
034	0001001000100001	1	1000000001000001	1	0100100000010001	1	0100000010000001	1
035	0001000100010001	1	1000000001000001	1	0010010000100001	1	0010000001000001	1
036	0000100100100001	1	0010000000100001	1	1001001000000010	2	0100100000000010	2
037	0000100010010001	1	1001001000010001	1	1000100100000010	2	0010010000000010	2
038	1001000000010001	1	1000100100010001	1	1000010010000010	2	1000100000000010	2
039	0010010000010001	1	1000010010010001	1	1000001001000010	2	0100010000000010	2
040	0001001000010001	1	1000000100000001	1	1000000100100010	2	0010001000000010	2
041	0000100100010001	1	0010000001000001	1	1000000010010010	2	1000010000000010	2
042	0000010010010001	1	0001000000100001	1	1000000001001010	2	0100001000000010	2
043	1001001000000010	2	0010010000000010	2	1001000100000010	2	0010000100000010	2
044	1000100100000010	2	0001001000000010	2	1000100010000010	2	1001001001000010	2
045	1000010010000010	2	0000100100000010	2	1000010001000010	2	1001000010010010	2
046	1000001001000010	2	0000010010000010	2	1000001000100010	2	1001000001001010	2
047	1000000100100010	2	0000001001000010	2	1000000100010010	2	1001000000100010	2
048	1000000010010010	2	1000100000000010	2	1000000010010010	2	1000001000000010	2
049	1000000001001010	2	0010001000000010	2	0100100100000010	2	0100100100100010	2
050	1001000100000010	2	0001000100000010	2	0100010010000010	2	0100100010010010	2
051	1000100010000010	2	0000100010000010	2	0100001001000010	2	0100100001001010	2
052	1000010001000010	2	0000010001000010	2	0100000100100010	2	0100000100100010	2
053	1000001000100010	2	0000001000100010	2	0100000010010010	2	0010010010010010	2
054	1000000100010010	2	1000010000000010	2	0100000001001010	2	0010010001001010	2
055	1000000010001010	2	0010000100000010	2	1001000010000010	2	0010000010000010	2
056	0000100000000010	2	0001000010000010	2	1000100001000010	2	1000000000100010	2
057	1001000010000010	2	0000100001000010	2	1000010000100010	2	0100000000010010	2
058	1000100001000010	2	0000010000100010	2	1000001000010010	2	1000000000010010	2
059	1000010000100010	2	0000001000010010	2	1000000100001010	2	0100000000100010	2
060	1000001000010010	2	1001001001000010	2	0100100010000010	2	0010000000010010	2

FIG. 12G

DATA SYMBOL	DCG31 Code Word MSB LSB	NCG	DCG32 Code Word MSB LSB	NCG	DCG41 Code Word MSB LSB	NCG	DCG42 Code Word MSB LSB	NCG
061	1000000100001001O	2	100100010010000010	2	010001000100000010	2	100100100000100010	2
062	001001001000000010	2	100100001001000010	2	010000100010000010	2	100001001000010010	2
063	001000100100000010	2	100100000100100010	2	010000010001000010	2	100001001000100010	2
064	001000010010000010	2	100000100000000010	2	010000001000100010	2	100000100100100010	2
065	001000001001000010	2	001001001001000010	2	001001001000000010	2	100000000100000010	2
066	001000000100100010	2	001001000100100010	2	001000100100000010	2	010000000001000010	2
067	000001000000000010	2	001000001000000010	2	001000010010000010	2	001000000000100010	2
068	100100100100100010	2	000100100100100010	2	001000001000100010	2	100100100000100010	2
069	100100000100000010	2	000100000100000010	2	001000000100100010	2	100100001000100010	2
070	100001000001000010	2	000010000010000010	2	100100100100100010	2	100001001000100010	2
071	100001000000100010	2	000001000001000010	2	100100000100000010	2	100001000100100010	2
072	100000100000100010	2	000000100000100010	2	100010000001000010	2	100001001001000010	2
073	001001000100000010	2	100000000000100010	2	100001000000100010	2	100001000100100010	2
074	001000100010000010	2	100000000001000010	2	100000100000100010	2	100000001000000010	2
075	001000010001000010	2	001000000000100010	2	010010000100000010	2	010010010000100010	2
076	001000001000100010	2	100100100000100010	2	010001000010000010	2	010001001001000010	2
077	000100100100000010	2	100010010000100010	2	100100000000100010	2	010000100100100010	2
078	000100001000100010	2	100001001000100010	2	010010000000100010	2	010000001000000010	2
079	000010010010000010	2	100000100100100010	2	001001000000100010	2	001000000010000010	2
080	000010001001000010	2	100000000100000010	2	100100000001000010	2	100100100010000010	2
081	000010000100100010	2	001000000001000010	2	100010000000100010	2	100100010001000010	2
082	100100000000100010	2	000100000000100010	2	010010000001000010	2	100100001000100010	2
083	001001000000100010	2	100100100001000010	2	010001000000100010	2	100010010010000010	2
084	000100100000100010	2	100100001000100010	2	001001000001000010	2	100010001001000010	2
085	000010010000100010	2	100010010001000010	2	001000100000100010	2	100010000100100010	2
086	000001001000100010	2	100010001000100010	2	100100000001000010	2	100000010000000010	2
087	000000100100100010	2	100001001001000010	2	100010000000100010	2	010010010001000010	2
088	100100000001000010	2	100001000100100010	2	100001000000100010	2	010010001000100010	2
089	100010000000100010	2	100000001000000010	2	010010000001000010	2	010001001001000010	2
090	001001000000100010	2	001000000001000010	2	010001000000100010	2	010001000100100010	2
091	001000100000100010	2	000100000000100010	2	010000100000100010	2	010000001000000010	2
092	000100100000100010	2	000010000000100010	2	001001000001000010	2	001001001000100010	2
093	000100010000100010	2	100100100001000010	2	001000100000100010	2	001000100100100010	2
094	000010010000100010	2	100100001000100010	2	001000010000100010	2	001000001000000010	2
095	000010001000100010	2	100100000100100010	2	100100100000000100	3	100100000000000100	3
096	000001001001000010	2	100010010010000010	2	100010010000000100	3	010010000000000100	3
097	000001000100100010	2	100010000100100010	2	100001001000000100	3	001001000000000100	3
098	100100000001000010	2	100010000100100010	2	100000100100000100	3	100100000000001000	3
099	100010000000100010	2	100000010000000010	2	100000010010000100	3	100010000000000100	3
100	100001000000100010	2	001001001000100010	2	100000001001001000	3	010010000000001000	3
101	001001000001000010	2	001000100100100010	2	010000000000100000	3	010001000000000100	3
102	001000100000100010	2	001000000100000010	2	001000000000001000	3	001001000000001000	3
103	001000010000100010	2	000100000001000010	2	100100100000001000	3	001000100000000100	3
104	000100100001000010	2	000010000000100010	2	100100001000000100	3	100100000000100000	3

FIG. 12J

DATA SYMBOL	DCG31		DCG32		DCG41		DCG42	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
241	1000000100000 1001	1	0010010010001 0001	1	0100100000001 0001	1	0100010010000 1001	1
242	0010000010001 0001	1	0010010001001 0001	1	0100010000000 1001	1	0100001001000 1001	1
243	0010000010001 1001	1	0010001001001 0001	1	0010010000001 0001	1	0100000100100 1001	1
244	0001000001001 0001	1	0010001000100 1001	1	0010001000000 1001	1	1001000100001 0001	1
245	0001000000100 1001	1	0001001001000 1001	1	1000100000001 0001	1	1001000010000 1001	1
246	1001001001000 1001	1	0001000100100 1001	1	1000010000000 1001	1	1000100001000 1001	1
247	1001000100100 1001	1	0000010000001 0001	1	0100010000001 0001	1	1000100001000 1001	1
248	1000010000001 0001	1	0000001000000 1001	1	0100001000000 1001	1	1000010001001 0001	1
249	1000001000000 1001	1	0010000000100 1001	1	0010001000001 0001	1	1000010000100 1001	1
250	0010000100001 0001	1	1001001000000 1001	1	0010000100000 1001	1	0100100100001 0001	1
251	0010000010000 1001	1	1000100100000 1001	1	0100010010000 1000	3	0100100100001 0000	3
252	0001000010001 0001	1	1000010010000 1001	1	0100010001000 0100	3	0100100010000 1000	3
253	0001000001000 1001	1	1000001001000 1001	1	0100001001000 1000	3	0100100001000 0100	3
254	0000100001001 0001	1	1000000100100 1001	1	0100001000100 0100	3	0100010010000 1000	3
255	0000100000100 1001	1	0010000000010 0001	1	0100000100100 1000	3	0100010001000 1000	3

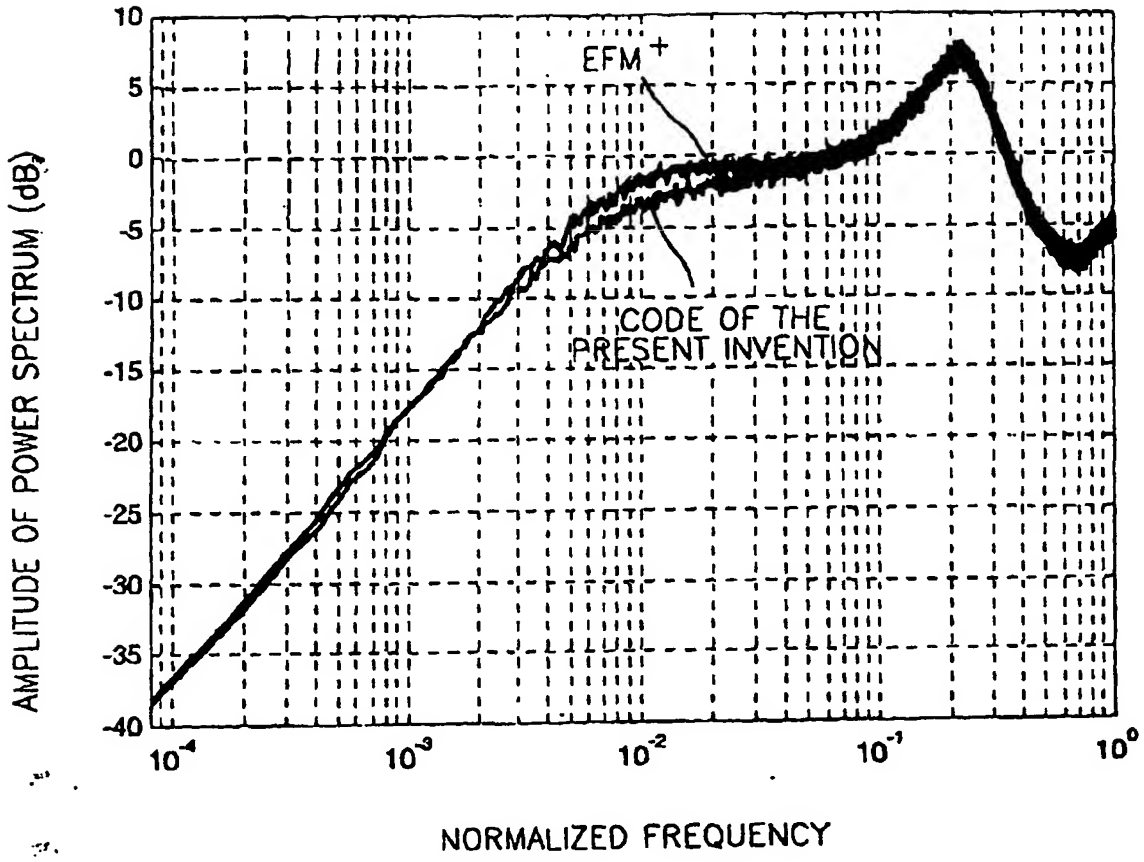
FIG. 13A

DATA SYMBOL	ACG1 Code Word MSB LSB	ACG1 NCG	ACG2 Code Word MSB LSB	ACG2 NCG	ACG3 Code Word MSB LSB	ACG3 NCG	ACG4 Code Word MSB LSB	ACG4 NCG
000	000001000000000	4	000001000000000	4	100100010000001	1	000001000000001	1
001	000010000000000	4	000010000000000	4	100100100000001	1	000010000000001	1
002	001001000000000	4	001001000000000	4	100100100100001	1	000100000000001	1
003	010001000000000	4	010001000000000	4	000000001000001	1	000001000100001	1
004	010010000000000	4	010010000000000	4	000000010000001	1	000001001000001	1
005	010010010001001	1	010010010010010	2	100100010000010	2	000010000100001	1
006	010010010010000	3			100100100000010	2	000010001000001	1
007	010010010010001	1			000000010010010	2	000010010000001	1
008	010010010010010	2			100100010010010	2	000100000100001	1
009					100100100010010	2	000100001000001	1
010					100100100100010	2	000100010000001	1
011					000000001000010	2	000100100000001	1
012					000000010000010	2	100100100100001	1
013					100100010000100	3	000100100100001	1
014					100100100000100	3	000010000000010	2
015					100100100001000	3	000100000000010	2
016					100100100100100	3	000001000100010	2
017					000000001000100	3	000001000100010	2
018					000000001001000	3	000001001000010	2
019					000000010000100	3	000010000010010	2
020					000000010001000	3	000010000100010	2
021					000000010010000	3	000010001000010	2
022					100100010001000	3	000010010000010	2
023					100100010010000	3	000100000100010	2
024					100100100010000	3	000100001000010	2
025					000000001000000	4	000100010000010	2
026					000000010000000	4	000100100000010	2
027					000001000000000	4	100100100100010	2
028					000010000000000	4	000100000010010	2
029					100100100000000	4	100100100010010	2
030					001001000000000	4	000001000000010	2
031					100001000000000	4	000010010010010	2
032					100010000000000	4	000100010010010	2
033					100100100100000	4	000100100010010	2
034					100100010001001	1	000100100100010	2
035					100100100001001	1	000100000000100	3
036					100100100010001	1	000001000100100	3
037					000000001001001	1	000001001000100	3
038					000000010001001	1	000001001001000	3
039					000000010010001	1	000010000100100	3
040					100100010010001	1	000010001000100	3
041							000010001001000	3
042							000010010000100	3
043							000010010001000	3
044							000100100010000	3
045							000100000100100	3
046							000100010000100	3
047							000100010001000	3
048							000100100000100	3
049							000100100001000	3
050							000100100010000	3
051							000100000100100	3
052							000100001001000	3
053							000100010010000	3
054							100100100100100	3
055							000001000000100	3
056							000001000001000	3
057							000001000010000	3
058							000010000000100	3
059							000010000001000	3
060							000010000010000	3

FIG. 13B

DATA SYMBOL	ACG1		ACG2		ACG3		ACG4	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
061							000100000001000	3
062							000100000010000	3
063							000100100100100	3
064							000100100100000	4
065							000001000000000	4
066							000010000000000	4
067							000001000100000	4
068							000001001000000	4
069							000010000100000	4
070							000010001000000	4
071							000010010000000	4
072							000100000100000	4
073							000100001000000	4
074							000100010000000	4
075							000100100000000	4
076							001001000000000	4
077							010001000000000	4
078							010010000000000	4
079							100001000000000	4
080							100010000000000	4
081							100100100100000	4
082							000100000001001	1
083							000001001001001	1
084							000010001001001	1
085							000010010001001	1
086							000010010010001	1
087							000100001001001	1
088							000100010001001	1
089							000100010010001	1
090							000100100001001	1
091							000100100010001	1
092							000001000001001	1
093							000001000010001	1
094							000010000001001	1
095							000010000010001	1
096							000100000010001	1
097							100100100010001	1

FIG. 14



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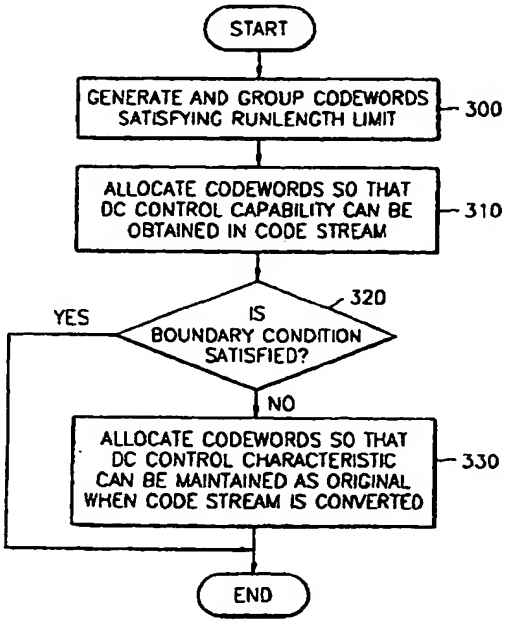
(54) Code generation and allocation method

(57) A method for generating and allocating codewords is provided. The method includes allocating one of two selectable codewords b1 and b2 as codeword b when a preceding codeword a and a following codeword b form a code stream X, in which codewords b1 and b2 have opposite INVs which are parameters indicating whether the number of '1s' contained in a codeword is an odd number or an even number and when the code stream of a and b1 is X1, and the code stream of a and b2 is X2, allocating codewords such that the INVs of X1 and X2 are maintained to be opposite when a or b1(b2) should be replaced by another codewords in compliance with a predetermined boundary condition given between codewords. According to the method, by using a short codeword having less bits as a main conversion codeword, high efficiency is achieved in recording density. Also, when codewords which do not satisfy the run length conditions are replaced by other codewords, the codewords are allocated so that the DC suppression capability of the code stream can be maintained, and therefore higher DC suppression capability of the code stream is provided.

FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 December 2004	Winkler, G

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